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Effects of Intensive Cropping Systems and Pesticides on Nematode Populations and Crop Yields

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Effects of Intensive Cropping Systems and Pesticides on Nematode Populations and Crop Yields

By A. W. Johnson,[1] C. C. Dowler,[2] N. C. Glaze,[3] and D. R. Sumner[4]

ABSTRACT

In a 4-year study, various combinations of eight crop plants were planted in six annual intensive cropping sequences on plots of Tifton, Carnegie, and Dothan loamy sands naturally infested with five nematode genera common in crop production fields in the Southeastern United States. The crops were cabbage, *Brassica oleracea* L.; corn, *Zea mays* L.; cucumbers, *Cucumis sativus* L.; peanuts, *Arachis hypogaea* L.; snap beans, *Phaseolus vulgaris* L.; southernpeas, *Vigna sinensis* (Torner) Savi; soybeans, *Glycine max* (L.) Merr.; and turnips, *Brassica rapa* L. Some plots were treated with the nematicide ethoprop (*O*-ethyl *S*,*S*-dipropyl phosphorodithioate) at the rate of 9 kg/ha of active ingredient, and various herbicides were used at appropriate points in cropping sequences. The turnip-peanut-snap bean and turnip-cucumber-southernpea-turnip sequences were the most effective cropping systems for suppressing most nematode species, and the turnip-corn-snap bean and turnip-corn-turnip sequences were the least effective. Ethoprop applied before corn, peanuts, and snap beans were planted did not consistently suppress nematode populations during the season or increase yields, but it did suppress root-gall development in cucumbers and increase yields each year. There was no evidence of residual effects of ethoprop on succeeding crops on most sampling dates. Nematode populations were not consistently affected by herbicides, but there were exceptions. Herbicides frequently increased populations of lesion nematodes, *Pratylenchus* spp., on corn and ring nematodes, *Macroposthonia ornata* (Raski) De Grisse and Loof, on peanuts and corn and decreased populations of root-knot nematodes, *Meloidogyne* spp., on corn; stubby-root nematodes, *Paratrichodorus minor* (Colbran) Siddiqi, on peanuts; and spiral nematodes, *Helicotylenchus dihystera* (Cobb) Sher., on corn, soybeans, and peanuts. Index terms: *Arachis hypogaea* L., *Brassica oleracea* L., *Brassica rapa* L., cabbage, corn, crop rotation, crop yields, cucumbers, *Cucumis sativas* L., ethoprop, *Glycine max* (L.) Merr., *Helicotylenchus dihystera* (Cobb) Sher., herbicides, intensive cropping systems, *Macroposthonia ornata* (Raski) De Grisse and Loof, *Meloidogyne incognita* (Kofoid and White) Chitwood, nematicides, nematodes, *Paratrichodorus minor* (Colbran) Siddiqi, peanuts, pesticides, *Phaseolus vulgaris* L., *Pratylenchus zeae* Graham, snap beans, Southeastern United States, southernpeas, soybeans, turnips, *Vigna sinensis* (Torner) Savi, *Zea mays* L.

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INTRODUCTION

Research has been conducted on the seasonal fluctuations in populations of plant-parasitic nematodes associated with given crop plants (Barker et al. 1969; Brodie et al. 1969, 1970; Cichorius 1960; Di Edwardo 1961; Ferris and Bernard 1961; Good 1972; Johnson et al. 1974, 1975; Sasser and Nusbaum 1955). Limited information is available concerning the effects of nematicides on field population densities of plant-parasitic nematodes in intensive cropping systems (Johnson and Campbell 1980; Johnson et al. 1978, 1981, 1979a, 1979b; Rhode et al. 1980; Sumner et al. 1975). No long-term field studies have been reported showing the effects of intensive cropping sequences of agronomic and horticultural crops on nematode populations. Our objectives in the 4-year experiment (1971–74) described herein were to study the effects of a nematicide (ethoprop) and various herbicides vs. cultivation on nematode population densities and the effects of nematodes on yields of crops in intensive cropping systems in the Southeastern Coastal Plain of the United States.

MATERIALS AND METHODS

Experimental design.—A 2-ha experimental area was established in 1971 at the Georgia Coastal Plain Experiment Station, Tifton, Ga., on Tifton, Carnegie, and Dothan loamy sands (about 75% sand, 16% silt, and 9% clay). The soils were naturally infested with mixed populations of root-knot nematodes, about 90% *Meloidogyne incognita* (Kofoid & White) Chitwood and 10% *M. hapla* Chitwood; lesion nematodes, about 85% *Pratylenchus zeae* Graham and 15% *P. brachyurus* (Godfrey) Filip. & Sch.-Stek.; stubby-root nematodes, *Paratrichodorus minor* (Colbran) Siddiqi; ring nematodes, *Macroposthonia ornata* (Raski) De Grisse & Loof; and spiral nematodes, *Helicotylenchus dihystera* (Cobb) Sher. The land had been in cultivation more than 30 years, primarily with corn, tobacco, soybeans, and small grains. The crops planted in this experiment were cabbage, *Brassica oleracea* L.; corn, *Zea mays* L.; cucumbers, *Cucumis sativas* L.; peanuts, *Arachis hypogaea* L.; snap beans, *Phaseolus vulgaris* L.; southernpeas, *Vigna sinensis* (Torner) Savi; soybeans, *Glycine max* (L.) Merr.; and turnips, *Brassica rapa* L.

A split-split-plot experiment with a randomized complete-block design of five replications was used. Three replicates were entirely on Tifton loamy sand, but small areas of Dothan or Carnegie loamy sands were on the periphery of the other two replicates. Whole plots were set up in the following six annual cropping sequences: turnip-corn-snap bean (T–C–SNB); turnip-peanut-snap bean (T–P–SNB); turnip-corn-turnip (T–C–T); turnip-peanut-turnip (T–P–T); snap bean-soybean-cabbage (SNB–SB–CB); and turnip-cucumber-southernpea-turnip (T–CU–SP-

Table 1.—Cultivars and planting dates for crops in intensive cropping systems, 1971–74

Crop	Cultivar	1971	1972	1973	1974
Turnip:[1]					
Spring		Feb. 18	Feb. 24	Feb. 23	Feb. 26
Fall		Sept. 9	Sept. 15	Sept. 18	Sept. 19
Snap bean:					
Spring	'GV 50'	Mar. 18	Mar. 21	Mar. 21[2]	[3]Mar. 20
Fall	'GV 50'	Sept. 8	Sept. 14	Sept. 14	Sept. 18
Corn	'Funks G4761'	Apr. 10	Apr. 18	Apr. 10	Apr. 10
Peanut	'Tifspan'	Apr. 10	Apr. 10	Apr. 10	Apr. 10
Soybean	'Davis'	June 1	May 9	June 20	June 20
Cucumber	'Chipper'	Apr. 12	Apr. 17	Apr. 18[4]	Apr. 24
Cabbage	'Market Prize'	Oct. 25	Nov. 3	Oct. 25	Oct. 25
Southernpea	'Pinkeye Purple Hull'	June 30	June 14	June 20	June 20

[1]The following cultivars were used in spring and fall crops: 'Purple Top' and 'White Globe', 1971–72; 'Shogoin', 1973–74.

[2]Replanted Apr. 18.

[3]Replanted Apr. 23.

[4]Replanted May 1.

T). The crops, varieties, and planting dates are listed in table 1. Crops in each sequence were grown in the same plots from February 1971 through January 1975. Subplots were nematicide vs. no nematicide and sub-subplots were herbicides vs. cultivation. Whole plots, subplots, and sub-subplots were 16.2 by 21.3 m, 9.1 by 16.2 m, and 8.1 by 9.1 m in size, respectively. Each sub-subplot contained five beds 1.6 by 9.1 m in size. Plants in the center bed were harvested for yield. Plant and soil samples for nematode assays were taken from the two beds adjacent to the middle bed.

Pesticide treatments.—A nematicide, *O*-ethyl *S,S*-dipropyl phosphorodithioate (ethoprop 10G), was broadcast at the rate of 9 kg/ha of active ingredient once each spring just before planting the crop in each sequence most susceptible to root-knot nematodes (corn, peanuts, snap beans, or cucumbers) and incorporated immediately into the top 15 cm of soil with a tractor-mounted rototiller. The herbicides used on all crops are listed in table 2. Each pesticide treatment and cropping sequence was maintained on the same sub-subplot for the duration of the experiment.

Cultural practices.—The soil was disk-harrowed and then turned under 25–30 cm deep with a moldboard plow after each crop was harvested. The next crop was planted within 2–7 days after incorporating residue from the preceding crop. Plots were clean-fallowed after the fall crops of snap beans and turnips were harvested. Based on soil tests, 5–10–15 fertilizer was applied to each crop as necessary for optimum production. Dolomitic limestone (6,729 kg/ha) was applied in April 1971 and again in February 1972. Soil pH was maintained between 6.0 and 6.7, as measured in a saturated paste. The soils contained approximately 1.0% organic matter (wet oxidation) and had a bulk density of 1.5–1.6 g/ml. Crops were irrigated as needed to maintain soil moisture near field capacity. Rainfall ranged from 113 to 135 cm/yr and from 1 to 27 cm/mo.

Nematode assay and root-gall evaluation.—Soil samples (20 cores, 2.1 by 20 cm) containing both rhizospheric and nonrhizospheric soil were collected monthly from within the rows of plants, beginning February 1971 and extending through January 1975 (except during December 1971, January and December 1972, and January 1973), to provide information on nematode population fluctuations. Soil samples were mixed thoroughly, and a 150-cm³ aliquant was processed by

Table 2.—Herbicides used on various crops in intensive cropping systems, 1971–74

Crop	Common name	Chemical name	Rate (kg a.i./ha)	Method of application
Corn	Butylate	*S*-ethyl diisobutylthiocarbamate	3.36	Injected at planting.
	Atrazine + phytoblend oil.	2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine	1.68	Over top of 10-cm-tall plants.
	Ametryn	2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-*s*-triazine	1.12	Directed postemergence spray in nitrogen solution 6 weeks after planting.
Peanut	Benefin	*N*-butyl-*N*-ethyl-α,α,α-trifluoro-2,6-dinitro-*p*-toluidine	1.4	Incorporated before planting.
	Vernolate	*S*-propyl dipropylthiocarbamate	2.24	Injected at planting.
	Dinoseb	2-*sec*-butyl-4,6-dinitrophenol	.56	Over top of crop as 5 repeated sprays.
Soybean	Vernolate	*S*-propyl dipropylthiocarbamate	2.24	Injected at planting.
	Chloroxuron	3-[*p*-(*p*-chlorophenoxy)phenyl]-1,1-dimethylurea	1.12	Directed spray to 8-cm-tall plants.
	Dinoseb	2-*sec*-butyl-4,6-dinitrophenol	.56	Directed spray to plants 15–20 cm tall.
	Linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	1.12	Directed spray to 38-cm-tall plants.
Turnip	DCPA	dimethyl tetrachloroterephthalate	8.96	Preemergence.
Southernpea & snap bean.	Trifluralin	α,α,α-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine	.56	Incorporated before planting.
	Dinoseb	2-*sec*-butyl-4,6-dinitrophenol	1.68	At ground-cracking.
Cabbage	DCPA	dimethyl tetrachloroterephthalate	8.96	At transplanting.
Cucumber	Nitralin	4-(methylsulfonyl)-2,6-dinitro-*N,N*-dipropylaniline	.84	Preemergence + irrigation.

a centrifugal-flotation method (Jenkins 1964) to separate nematodes from the soil. Nematode population densities were expressed as the number of nematodes per 150 cm^3 of soil.

At harvest, 20 plants were removed from each plot, except those planted to corn and peanuts, and rated on a scale of 1 to 5 for percentage of roots galled by root-knot nematodes, as follows: 1=no galling, 2=1–25, 3=26–50, 4=51–75, and 5=76–100.

Turnips, corn, soybeans, and peanuts were harvested mechanically, and snap beans, cabbage, cucumbers, and southernpeas were hand-harvested. Yields were recorded in kilograms per hectare.

RESULTS

Nematode population densities.—Population densities of root-knot nematodes were influenced by different cropping systems and crops within each system (figs. 1–4). The highest numbers occurred in the SNB–SB–CB and T–CU–SP–T sequences. Numbers of root-knot nematodes in the SNB–SB–CB sequence were highest on soybeans in October of each year (fig. 1). Numbers of these nematodes on snap beans were low to moderate. Application of ethoprop immediately before snap beans were planted did not suppress root-knot nematodes or prevent increase of nematode populations on succeeding crops. Cabbage supported low numbers of root-knot nematodes. Numbers of these nematodes in the T–CU–SP–T sequence were highest in July and August of each year on southernpeas following cucumbers and lowest following the two crops of turnips (fig. 2). Application of ethoprop immediately before cucumbers were planted caused a significant reduction in numbers of root-knot nematodes in plots planted to southernpeas in 1971 and 1972 but not in 1973 and 1974.

Population densities of root-knot nematodes in the T–C–SNB (fig. 3) and T–C–T (fig. 4) sequences did not increase to high levels during 1971 and 1972, but they increased rapidly on corn in August 1973 and 1974 in both cropping sequences and on snap beans following corn in 1973. During this period, numbers of root-knot nematodes were lower in corn and snap bean plots treated with herbicides alone or ethoprop + herbicides than in plots treated with ethoprop alone or untreated controls. Population densities of these nematodes were near or below detectable levels in the T–P–SNB and T–P–T sequences on most sampling dates.

The highest numbers of lesion nematodes occurred on corn in July 1971 and 1972 and in August 1973 and 1974 in the T–C–T (fig. 5) and T–C–SNB (fig. 6) sequences. Numbers of these nematodes in both cropping sequences were consistently higher in plots of corn treated with herbicides alone than in any of the other plots. Application of ethoprop before corn was planted in the T–C–T sequence prevented a rapid increase in lesion nematodes on corn in 1971 and 1972 but not in 1973 and 1974, when compared with the numbers of these nematodes in untreated plots. Numbers of lesion nematodes in the T–C–T sequence declined after the second crop of turnips and were usually at the lowest levels when corn was planted in April. Numbers of these nematodes on the fall crop of snap beans in the T–C–SNB cropping sequence were erratic, but they were lower in ethoprop-treated plots than in untreated plots in November of 3 consecutive years, 1971–73 (fig. 6). Numbers of lesion nematodes declined on turnips in the T–C–SNB cropping sequence and were low when corn was planted in April.

Numbers of lesion nematodes increased rapidly on soybeans following snap beans in the SNB–SB–CB sequence in 1971 but were not >50 per 150 cm^3 of soil on any crop after the first crop of cabbage (fig. 7). Application of ethoprop before snap beans were planted did not reduce numbers of these nematodes, but numbers in soybean plots following snap beans were lower in ethoprop-treated plots than in untreated plots in September and October 1971. Population densities of lesion nematodes were near or below detectable levels in the T–P–SNB, T–P–T, and T–CU–SP–T cropping sequences on most sampling dates.

Population densities of stubby-root nematodes increased most on corn in the T–C–SNB and T–C–T cropping sequences (figs. 8 and 9). Numbers were usually highest on corn during June of each year. Application of ethoprop before corn was planted in the T–C–SNB sequence suppressed numbers of stubby-root nematodes during May 1971 and June 1972, but these nematodes increased in ethoprop-treated plots during 1973 and 1974. In the T–C–T cropping sequence, numbers of stubby-root nematodes were reduced in ethoprop-treated plots in 1971 (May) and 1973 (June), but not in 1972 and 1974. Numbers of

these nematodes were usually <20 per 150 cm^3 of soil on turnips in any cropping sequence. Population densities of stubby-root nematodes were <20 per 150 cm^3 of soil on all crops in the T-P-SNB and T-P-T sequences (figs. 10 and 11). Numbers of these nematodes in untreated plots of peanuts were higher than numbers in plots treated with ethoprop alone, herbicides alone, or ethoprop + herbicides in 3 of the 4 years. Numbers of stubby-root nematodes were <10 per 150 cm^3 of soil on most sampling dates in the SNB-SB-CB and T-CU-SP-T sequences (figs. 12 and 13). Application of ethoprop before snap beans were planted suppressed numbers of these nematodes in 1971 (May) and 1972 (May), but not in 1973 and 1974.

Numbers of ring nematodes were higher on peanuts and corn than on other crops in the various cropping sequences (figs. 14-17). Numbers of these nematodes on peanuts in the T-P-T sequence were lower in plots treated with ethoprop alone or ethoprop + herbicides than in plots treated with herbicides alone or untreated plots during June and July 1971 (fig. 14). Each year thereafter, numbers of ring nematodes on peanuts in August and September were higher in plots treated with herbicides alone than in any of the other plots. Numbers of these nematodes on peanuts in the T-P-SNB sequence were lower in plots treated with ethoprop alone, herbicides alone, or ethoprop + herbicides than in untreated plots in June and July 1971 (fig. 15). In August 1973 and 1974, numbers of ring nematodes on peanuts were higher in plots treated with herbicides alone than in any of the other plots. In the T-C-T sequence, numbers of these nematodes in plots of corn treated with ethoprop alone or ethoprop + herbicides were lower than in any of the other plots in July 1971 (fig. 16). During July and August 1972, numbers of ring nematodes in all treated plots were lower than those in untreated plots. In August 1973 and July 1974, numbers of these nematodes were higher in plots treated with ethoprop alone than in any of the other plots. A similar trend occurred with corn in the T-C-SNB cropping sequence (fig. 17). Numbers of ring nematodes were lowest following turnips in April before corn was planted. Population densities of ring nematodes were <20 per 150 cm^3 of soil on crops in the SNB-SB-CB and T-CU-SP-T sequences and were not affected by soil chemical treatments.

Numbers of spiral nematodes were at the highest levels after the third crop of corn in the T-C-T sequence (fig. 18). Numbers of these nematodes were lower in June and July 1972 in plots treated with ethoprop alone or ethoprop + herbicides than in untreated plots. Numbers of spiral nematodes in untreated plots were higher than those in plots treated with herbicides, ethoprop, or ethoprop + herbicides on most sampling dates in 1973 and 1974. These nematodes also increased in untreated plots of soybeans in the SNB-SB-CB sequence but were suppressed by all soil chemical treatments on most sampling dates (fig. 19). Ethoprop alone and ethoprop + herbicides suppressed numbers of spiral nematodes on corn in the T-C-SNB sequence during June and July 1971 but did not during the last 3 years of the study (fig. 20). All chemical treatments reduced numbers of spiral nematodes on the first and fourth crops of peanuts in the T-P-T sequence during June, July, and August 1971 and July and August 1974 (fig. 21). Numbers of these nematodes were lowest following the second crop of turnips in the T-P-T cropping sequence. Numbers of spiral nematodes were <60 per 150 cm^3 of soil on all crops in the T-P-SNB and T-CU-SP-T sequences and were not affected by soil chemical treatments.

Root-gall indices.—Root-galling of crops in the T-C-SNB, T-P-SNB, T-C-T, T-P-T, and SNB-SB-CB sequences was not significantly affected by ethoprop. Root-gall indices of cucumbers in the T-CU-SP-T sequence were lower each year in ethoprop-treated plots than in untreated plots (table 3). Root-gall indices of southernpeas following cucumbers in plots treated with ethoprop were lower than those in untreated plots in 1971 and 1972 but not in 1973 and 1974.

Influence of ethoprop and herbicides on yield.—Data from subplots (nematicide vs. no nematicide) indicate that an annual application of ethoprop before corn, peanuts, and snap beans were planted did not increase yields of these crops or succeeding crops (tables 4-8). Yields of snap beans in the SNB-SB-CB sequence were lower in ethoprop-treated plots than in untreated plots in 1972, but yields were not affected by the nematicide during the other 3 years. Yields of cucumbers in the T-CU-SP-T sequence were higher each year in ethoprop-treated plots than in untreated plots, but yields of succeeding crops were not affected by the nematicide (table 9).

Data from sub-subplots (herbicides vs. cultiva-

(*Continued on page 13.*)

Table 3.—Effects of ethoprop and herbicides on root-gall indices for a turnip-cucumber-southernpea-turnip cropping sequence, 1971-74[1]

Treatment[2]	Turnip	Cucumber[3]	Southern-pea	Turnip	Turnip	Cucumber[3]	Southern-pea	Turnip
	1971				1972			
C	1.04	2.06a	2.72a	1.09	1.00	2.56a	2.68a	2.26
H	1.00	1.96ab	2.10ab	1.08	1.00	3.28a	1.92b	2.38
NC	1.00	1.22bc	1.44b	1.04	1.00	1.42b	1.36c	1.80
NH	1.04	1.08c	1.70b	1.06	1.00	1.36b	1.46bc	1.80
Mean:								
Nematicide:								
No	1.02	2.01a	2.41a	1.09	1.00	2.92a	2.30a	2.32
Yes	1.02	1.15b	1.57b	1.05	1.00	1.39b	1.41b	1.80
Herbicide:								
No	1.02	1.64	2.08a	1.07	1.00	1.99	2.02a	2.03
Yes	1.02	1.52	1.90b	1.07	1.00	2.32	1.69b	2.09
	1973				1974			
C	1.50a	2.84	2.42a	1.14	1.00	2.06ab	1.92b	1.04
H	1.22ab	3.20	2.58a	1.08	1.00	2.50a	3.10a	1.20
NC	1.06b	1.94	2.48a	1.42	1.00	1.20c	2.50ab	1.06
NH	1.12b	1.58	1.90b	1.00	1.00	1.46ab	2.24b	1.12
Mean:								
Nematicide:								
No	1.35a	3.02a	2.50	1.11	1.00	2.28a	2.51	1.12
Yes	1.09b	1.76b	2.19	1.21	1.00	1.33b	2.37	1.09
Herbicide:								
No	1.28	2.39	2.45	1.28	1.00	1.63	2.21	1.05
Yes	1.17	2.39	2.24	1.04	1.00	1.98	2.67	1.16

[1]Plants were rated on a scale of 1 to 5 for percentage of roots galled by root-knot nematodes: 1=no galling; 2=1–25; 3=26–50; 4=51–75; 5=76–100. Indices for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

Table 4.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a turnip-corn-snap bean cropping sequence, 1971–74[1]

Treatment[2]	Turnip	Corn[3]	Snap bean	Turnip	Corn[3]	Snap bean[4]
	1971			1972		
C	18,892	8,858	2,410	15,596ab	5,945b	3,321
H	18,715	8,717	2,538	14,289ab	8,802a	2,948
NC	18,947	8,412	2,257	16,115a	6,989b	3,247
NH	17,684	8,351	2,544	13,643b	9,266a	2,868
Mean:						
Nematicide:						
No	18,804	8,788	2,474	14,943	7,374	3,135
Yes	18,316	8,382	2,401	14,879	8,128	3,058
Herbicide:						
No	18,920	8,635	2,334	15,856a	6,467b	3,284
Yes	18,200	8,534	2,541	13,966b	9,034a	2,908
	1973			1974		
C	11,682	5,478b	1,068	16,671	6,059	....
H	9,339	7,967a	1,190	11,450	6,890	....
NC	11,249	5,948b	885	17,598	7,329	....
NH	7,534	7,991a	1,202	11,999	7,090	....
Mean:						
Nematicide:						
No	10,511	6,723	1,129	14,061	6,475	....
Yes	9,392	6,970	1,044	14,799	7,210	....
Herbicide:						
No	11,466a	5,713b	977	17,135a	6,694	....
Yes	8,437b	7,979a	1,196	11,725b	6,990	....

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

[4]No yield data available for 1974.

Table 5.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a turnip-peanut-snap bean cropping sequence, 1971–74[1]

Treatment[2]	Turnip	Peanut[3]	Snap bean	Turnip	Peanut[3]	Snap bean[4]
	1971			1972		
C	18,679	702b	2,355	15,687a	623ab	3,998a
H	17,227	3,162a	2,581	13,032b	1,025ab	2,448b
NC	16,806	1,123b	2,391	13,520b	501b	4,077a
NH	17,417	3,221a	2,324	12,910b	1,520a	2,667b
Mean:						
Nematicide:						
No	17,953	1,932	2,468	14,360	824	3,223
Yes	17,112	2,172	2,358	13,215	1,011	3,372
Herbicide:						
No	17,243	913b	2,373	14,604a	562b	4,038a
Yes	17,322	3,192a	2,453	12,971b	1,273a	2,558b
	1973			1974		
C	7,539	49b	1,678	18,971a	42b	....
H	6,844	1,269a	1,330	10,467b	2,122a	....
NC	11,065	55b	1,745	16,714a	67b	....
NH	7,430	1,421a	1,141	11,260b	1,824a	....
Mean:						
Nematicide:						
No	7,192	659	1,504	14,719	1,082	....
Yes	9,248	738	1,443	13,987	946	....
Herbicide:						
No	9,302a	52b	1,712	17,843a	55b	....
Yes	7,137b	1,345a	1,236	10,864b	1,973a	....

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

[4]No yield data available for 1974.

Table 6.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a turnip-corn-turnip cropping sequence, 1971-74[1]

Treatment[2]	Turnip	Corn[3]	Turnip	Turnip	Corn[3]	Turnip
		1971			1972	
C	18,501	9,161	23,424	16,267	7,599	26,539
H	16,556	8,723	21,393	12,819	8,479	19,674
NC	18,313	9,474	21,716	16,359	8,765	27,223
NH	18,038	8,662	19,941	14,417	8,820	21,205
Mean:						
Nematicide:						
No	17,529	8,946	22,409	14,543	8,039	23,107
Yes	18,176	9,068	20,829	15,388	8,793	24,214
Herbicide:						
No	18,407	9,322	22,570a	16,313a	8,182	26,881a
Yes	17,297	8,693	20,667b	13,618b	8,650	20,440b
		1973			1974	
C	10,230	4,996b	14,707	14,646	5,932b	13,200a
H	7,632	8,498a	8,864	11,157	7,157a	6,771b
NC	10,718	6,783a	13,255	14,658	7,101a	15,055a
NH	7,528	7,564a	5,728	10,760	6,791ab	7,704b
Mean:						
Nematicide:						
No	8,931	6,747	11,786	12,902	6,545	9,986
Yes	9,123	7,174	9,492	12,709	6,946	11,380
Herbicide:						
No	10,474a	5,890b	13,981a	14,652a	6,517	14,128a
Yes	7,580b	8,031a	7,296b	10,958b	6,974	7,238b

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

Table 7.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a turnip-peanut-turnip cropping sequence, 1971–74[1]

Treatment[2]	Turnip	Peanut[3]	Turnip	Turnip	Peanut[3]	Turnip
	1971			1972		
C	17,794	641b	23,887	14,326a	378b	24,301
H	16,867	2,898a	21,459	12,910ab	1,843a	25,104
NC	18,318	1,184b	22,845	14,253a	732ab	26,325
NH	17,105	2,989a	22,729	11,933b	1,709a	20,630
Mean:						
Nematicide:						
No	17,331	1,770	22,673	13,618	1,111	24,703
Yes	17,712	2,087	22,787	13,093	1,221	23,478
Herbicide:						
No	18,056	913b	23,366	14,290a	555b	23,313
Yes	16,986	2,944a	22,094	12,422b	1,776a	22,867
	1973			1974		
C	9,644a	86b	15,720	9,571	128b	12,133a
H	4,569b	2,190a	6,991	8,595	2,476a	6,106bc
NC	7,723a	98b	13,951	11,077	55b	9,278ab
NH	5,197b	2,593a	7,759	8,894	2,525a	4,733c
Mean:						
Nematicide:						
No	7,107	1,138	11,356	9,083	1,302	9,120
Yes	6,460	1,346	10,855	9,986	1,290	7,006
Herbicide:						
No	8,684a	92b	14,836a	10,324a	92b	10,706a
Yes	4,883b	2,392a	7,375b	8,745b	2,501a	5,420b

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

Table 8.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a snap bean-soybean-cabbage cropping sequence, 1971–74[1]

Treatment[2]	Snap bean[3]	Soybean	Cabbage[4]	Snap bean[3]	Soybean	Cabbage
	1971			1972		
C	5,612	2,837b	....	3,870a	671b	2,104c
H	5,704	3,489a	....	3,833a	1,416a	3,222a
NC	4,587	2,501b	....	2,234b	378b	2,562b
NH	5,320	3,703a	....	2,704b	1,202a	2,074c
Mean:						
Nematicide:						
No	5,658	3,163	....	3,852a	1,044	2,663a
Yes	4,954	3,102	....	2,469b	790	2,318b
Herbicide:						
No	5,100	2,669b	....	3,052	525b	2,333
Yes	5,512	3,596a	....	3,269	1,309a	2,648
	1973			1974		
C	2,032b	568b	....	939ab	335b	31,378
H	4,154a	2,044a	....	1,933a	2,446a	31,469
NC	1,940b	513b	....	481b	201b	32,268
NH	4,490a	1,891a	....	1,756a	2,354a	28,480
Mean:						
Nematicide:						
No	3,093	1,306	....	1,436	1,391	31,424
Yes	3,215	1,202	....	1,119	1,278	30,374
Herbicide:						
No	1,986b	541b	....	710b	268b	31,823
Yes	4,322a	1,968a	....	1,845a	2,400a	29,975

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

[4]Crop destroyed by freeze in 1971; no yield data available for 1973.

Table 9.—Effects of ethoprop and herbicides on yields (kg/ha) of crops in a turnip-cucumber-southernpea-turnip cropping sequence, 1971–74[1]

Treatment[2]	Turnip	Cucumber[3]	Southern-pea	Turnip	Turnip	Cucumber[3]	Southern-pea	Turnip
	1971				1972			
C	16,598a	3,318c	3,847ab	19,105	13,612ab	1,703b	1,093	19,002b
H	15,415b	8,729b	4,466a	15,231	11,103b	5,335ab	1,147	12,588c
NC	17,257a	5,350bc	3,691b	19,239	15,013a	6,409a	1,471	23,788a
NH	15,659b	12,719a	4,093a	17,342	11,280b	8,948a	1,349	20,453ab
Mean:								
Nematicide:								
No	16,007	6,024b	4,170	17,168	12,358	3,519b	1,120	15,795
Yes	16,458	9,035a	3,892	18,291	13,147	7,679a	1,410	22,121
Herbicide:								
No	16,928a	4,334b	3,783b	19,172a	14,313a	4,056b	1,282	21,395a
Yes	15,537b	10,724a	4,280a	16,287b	11,192b	7,142a	1,248	16,521b
	1973				1974			
C	10,529a	3,953b	1,806	11,560	12,724a	3,959c	835	8,351b
H	6,436b	6,094b	1,607	7,101	5,423c	5,044bc	848	6,710b
NC	8,522ab	8,888ab	1,897	14,091	10,040ab	9,845a	847	13,908a
NH	5,533b	11,358a	1,904	1,659	7,405bc	6,935b	780	4,386c
Mean:								
Nematicide:								
No	8,483	5,024b	1,707	9,331	9,074	4,502b	842	7,531
Yes	7,028	10,123a	1,901	7,875	8,723	8,390a	814	9,147
Herbicide:								
No	9,526a	6,421b	1,852	12,826a	11,382a	6,902	841	11,130a
Yes	5,985b	8,726a	1,756	4,380b	6,414b	5,990	814	5,548b

[1]Means for the same treatment category (C, H, NC, and NH) and for nematicide or herbicide in the same column for a given year followed by unlike letters are significantly different at the 5% level according to Duncan's multiple-range test.

[2]C, cultivation (untreated control). H, herbicide. NC, nematicide + cultivation. NH, nematicide + herbicide.

[3]Ethoprop 10G was applied (8.96 kg/ha of active ingredient) and incorporated into the soil 15 cm deep with a tractor-powered rototiller just before planting each year. Ethoprop was not applied before planting other crops. Herbicides were applied to each crop each year for weed control.

tion) indicate that yields of certain crops were affected by herbicides (tables 4–9). Yields of spring turnips in all cropping sequences involving turnips, except T–CU–SP–T, were not affected by herbicides in 1971 but were reduced by them each succeeding year. Yields of spring turnips in the T–CU–SP–T cropping sequence were retarded by herbicides each year. Yields of corn in the T–C–SNB sequence were not affected by herbicides in 1971 and 1974 but were increased by them in 1972 and 1973. Yields of peanuts and soybeans in all cropping sequences involving these crops were consistently lower in cultivated plots than in herbicide-treated plots. Cucumber yields in herbicide-treated plots were higher than yields in cultivated plots during 1971–73 but not in 1974. Yields of fall snap beans in the T–C–SNB and T–P–SNB sequences were not increased by herbicides. Application of herbicides increased yields of southernpeas in the T–CU–SP–T sequence in 1971 but not thereafter. Yields of fall turnips in the T–C–T and T–CU–SP–T sequences were lower in herbicide-treated plots than in cultivated plots each year. Yields of fall turnips in the T–P–T sequence were not affected by herbicides in 1971 and 1972, but yields were lower in herbicide-treated plots than in cultivated plots in 1973 and 1974. Yields of cabbage were not affected by herbicides.

DISCUSSION

The experimental variables used in this study were limited to ethoprop vs. no nematicide, herbicides vs. cultivation, and cropping sequences.

Application of ethoprop before corn, peanuts, and snap beans were planted did not suppress nematode populations consistently during the season or increase yields. These results indicate that the nematode populations were below the threshold level or that ethoprop was not lethal to them. Rohde et al. (1980) reported that populations of root-knot nematodes, *M. incognita*, were not suppressed when treated with ethoprop (8.96 kg/ha of active ingredient) in plots of field corn and southernpeas in a turnip-field corn-southernpea cropping sequence. In our study, populations of *Pratylenchus* spp., *P. minor*, and *H. dihystera* on corn and *P. minor* on snap beans were suppressed by ethoprop in 1971 and 1972 but not in 1973 and 1974. These results indicate that under an intensive multiple-crop system, where ethoprop is applied to the same area annually, a population shift to ethoprop-tolerant nematodes might evolve.

The low yield of spring snap beans in 1972 was attributed to nematodes and soil-borne fungi. We previously reported the effects of ethoprop and other pesticides on root diseases of the snap bean and the southernpea in these intensive cropping systems (Sumner et al. 1978).

Numbers of *M. incognita* larvae in plots following fall and spring turnips were near or below detectable levels when cucumbers were planted; however, application of ethoprop consistently reduced root-galling in cucumbers and increased yields. Most of the yield increase was attributed to control of root-knot nematodes. However, Sumner (1978) reported that ethoprop reduced the severity of root disease in cucumbers caused by *Rhizoctonia solani* Kuehn (AG–4) but did not influence root diseases caused by other soil-borne pathogens under greenhouse conditions.

We conclude that a single application of ethoprop (8.96 kg/ha of active ingredient) before planting of crops tolerant of *M. incognita* and nonhost crops, such as corn and peanuts, respectively, is not beneficial for controlling nematodes or for improving yields when numbers of nematodes in the soil are low. However, a single application of the nematicide before planting of a crop susceptible to *M. incognita*, such as cucumbers, will provide protection from nematodes and increase yields.

The lack of residual nematode control by ethoprop in succeeding crops was not surprising. We previously reported that ethoprop is not a persistent chemical in coastal plain soils and that the half-life ranges from 3 to 15 days under field conditions (Rohde 1980).

Nematode populations were not consistently affected by herbicides on most sampling dates, but there were exceptions. Herbicides frequently increased populations of *Pratylenchus* spp. on corn and *M. ornata* on peanuts and corn and decreased populations of *M. incognita* on corn, *P. minor* on peanuts, and *H. dihystera* on corn, soybeans, and peanuts. We do not know if these differences were caused by a direct effect of the herbicides on the nematodes in the soil or in the roots of crop hosts, by an indirect effect through reduction of weed hosts in herbicide-treated plots, or by the influence of the herbicides on the soil microfauna and microflora. In field tests on single-crop and multiple-crop systems (Johnson et al. 1975), herbicides did not significantly affect nematode

Table 10.—Suitability ratings of cropping sequences for use in managing plant-nematode populations, 1971–74

Cropping sequence[1]	Ratings based on number of nematodes per 150 cm^3 of soil for—				
	M. incognita[2]	*Pratylenchus* spp.[3]	*P. minor*[4]	*M. ornata*[5]	*H. dihystera*[6]
T-C-SNB	Fair,[7] Poor[8]	Poor	Poor	Fair	Fair
T-P-SNB	Good	Good	Good	Poor	Good
T-C-T	Good,[7] Fair[8]	Poor	Poor	Poor	Fair,[7] Poor[8]
T-P-T	Good	Good	Good	Poor	Fair
SNB-SB-CB	Poor	Poor,[7] Good[8]	Good	Good	Poor
T-CU-SP-T	Poor	Good	Good	Good	Good

[1]T, turnip. C, corn. SNB, snap bean. P, peanut. SB, soybean. CB, cabbage. CU, cucumber. SP, southernpea.
[2]Good=<140; Fair=140–420; Poor=>420.
[3]Good=<20; Fair=20–40; Poor=>40.
[4]Good=<20; Fair=20–50; Poor=>50.
[5]Good=<30; Fair=30–120; Poor=>120.
[6]Good=<130; Fair=130–260; Poor=>260.
[7]Suitability rating for 1971–72.
[8]Suitability rating for 1973–74.

population densities on corn, peanuts, soybeans, and cotton.

Table 10 gives the suitability ratings, based on the nematode population data in figures 1–21, of each intensive cropping sequence for use in managing plant-nematode populations. The T–P–SNB and T–CU–SP–T sequences were the most effective cropping systems for suppressing most nematode species; however, *M. ornata* increased in the T–P–SNB sequence, and *M. incognita* increased in the T–CU–SP–T sequence. The T–C–SNB and T–C–T cropping sequences were the poorest systems used to suppress nematode populations, primarily because they favored rapid increase of five potentially damaging nematode species, *M. incognita, P. zeae, P. minor, M. ornata,* and *H. dihystera.* The other intensive cropping systems were intermediate in suppressing nematodes. Low densities of *M. incognita,* one of the most common and damaging *Meloidogyne* species in North and South America (Taylor and Sasser 1978) on peanuts, were expected because the peanut is a nonhost for this nematode species (Good 1972; Johnson et al. 1974, 1975; Sasser and Nusbaum 1955). Following peanuts, neither turnips nor snap beans was damaged by *M. incognita.* Therefore, these results demonstrate the value of integrating nonhost crops with susceptible crops to minimize damage caused by root-knot nematodes.

Numbers of most nematodes were near or below detectable levels after one crop of cabbage and two crops of turnips. The decrease in plant-parasitic nematode populations, which often occurs after the addition of various organic soil amendments, has been attributed to predaceous fungi, nematode-trapping fungi, toxins from fungi and higher plants, changes in osmotic pressures within the soil environment, and ammonification during decomposition (Walker 1971). We are unaware of any research relating to the influence of crop residues on plant-parasitic nematodes under field conditions. Any one or more of the above factors could have enhanced the suppression of nematodes in these intensive cropping sequences.

Our data indicate that no single cropping sequence used will suppress all plant nematodes present in the test area. Furthermore, the data support and extend previously reported results of nematodes on agronomic crops (Johnson et al. 1974, 1975). In addition to identifying the suitability of certain crop plants as hosts to *M. incognita, Pratylenchus* spp., *P. minor, M. ornata,* and *H. dihystera,* we have established the importance of growing agronomic-vegetable and all vegetable crops in succession to produce three or four crops each year from the same land area.

This integrated pest-management study utilized cultural practices such as destruction of crop residues immediately after harvest, clean fallowing from time of harvest until the succeeding crops were planted, crop rotation, planting of nonhost crops, and application of a nematicide to reduce nematode survival and thus reduce inoculum levels for the subsequent crops. Addition-

al studies are planned that will utilize the described methods along with resistant varieties and various tillage practices to manage nematode populations in intensive crop-production systems.

Our data can be used as a guide in selecting crops and varieties for intensive cropping sequences in nematode-infested soils of the Southeastern Coastal Plains of the United States.

REFERENCES

Barker, K. R.; Nusbaum, C. J.; and Nelson, L. A.
1969. Seasonal population dynamics of selected plant-parasitic nematodes as measured by three extraction procedures. J. Nematol. 1: 232–239.

Brodie, B. B.; Good, J. M.; and Adams, W. E.
1969. Population dynamics of plant-parasitic nematodes in cultivated soil: effect of sod-based rotations in Cecil sandy loam. J. Nematol. 1: 309–312.

Brodie, B. B.; Good, J. M.; and Marchant, W. H.
1970. Population dynamics of plant nematodes in cultivated soil: effect of sod-based rotations in Tifton sandy loam. J. Nematol. 2: 135–138.

Cichorius, H.-D.
1960. Über das auftreten freilebender Wurzelnematoden in rheinischen Böden unter besonderer Berücksichtigung der Standortverhältnisse. Nematologica 5: 231–252.

Di Edwardo, A. A.
1961. Seasonal population variations of *Pratylenchus penetrans* in and about strawberry roots. Plant Dis. Rep. 45: 65–71.

Ferris, V. R., and Bernard, R. L.
1961. Seasonal variations of nematode populations in soybean field soil. Plant Dis. Rep. 45: 789–793.

Good, J. M.
1972. Management of plant-parasitic nematode populations. Proceedings of the Tall Timbers Conference on Ecological Animal Control by Habitat Management 4: 109–127.

Jenkins, W. R.
1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Rep. 48: 692.

Johnson, A. W., and Campbell, G. M.
1980. Managing nematode population densities on tomato transplants using crop rotation and a nematicide. J. Nematol. 12: 6–19.

Johnson, A. W.; Dowler, C. C.; and Hauser, E. W.
1974. Seasonal population dynamics of selected plant-parasitic nematodes on four monocultured crops. J. Nematol. 6: 187–190.
1975. Crop rotation and herbicide effects on population densities of plant-parasitic nematodes. J. Nematol. 7: 158–168.

Johnson, A. W.; Jaworski, C. A.; and Sumner, D. R.
1978. Effects of soil treatments on yields of sequentially cropped cucumbers and nematode and fungus populations. J. Nematol. 10: 291. (Abstr.)

Johnson, A. W.; Rohde, W. A.; Dowler, C. C.; Glaze, N. C.; and Wright, W. C.
1981. Influence of water and soil temperature on the concentration and efficacy of phenamiphos for control of root-knot nematodes. J. Nematol. 12: 33–39.

Johnson, A. W.; Sumner, D. R.; and Jaworski, C. A.
1979a. Effects of management practices on nematode and fungus populations and cucumber yield. J. Nematol. 11: 84–93.
1979b. Effect of film mulch, trickle irrigation, and DD-MENCS on nematodes, fungi, and vegetable yields in a multicrop production system. Phytopathology 69: 1172–1175.

Rohde, W. A.; Johnson, A. W.; Dowler, C. C.; and Glaze, N. C.
1980. Influence of climate and cropping patterns on the efficacy of ethoprop, methyl bromide, and DD-MENCS for control of root-knot nematodes. J. Nematol. 12: 33–39.

Sasser, J. N., and Nusbaum, C. J.
1955. Seasonal fluctuations and host specificity of root-knot nematode populations in two-year tobacco rotation plots. Phytopathology 45: 540–545.

Sumner, D. R.
1978. Interactions of herbicides and ethoprop with root diseases of cucumber. Plant Dis. Rep. 62: 1093–1097.

Sumner, D. R.; Johnson, A. W.; Glaze, N. C.; and Dowler, C. C.
1975. Disease, nematode, and weed control in intensive cropping systems. Ga. Agric. Res. 16(4): 4–5, 7.
1978. Root diseases of snap bean and southernpea in intensive cropping systems. Phytopathology 68: 955–961.

Taylor, A. L., and Sasser, J. N.
1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). 111 pp. Department of Plant Pathology, North Carolina State University, Raleigh.

Walker, J. T.
1971. Populations of *Pratylenchus penetrans* relative to decomposing nitrogenous soil amendments. J. Nematol. 3: 43–49.

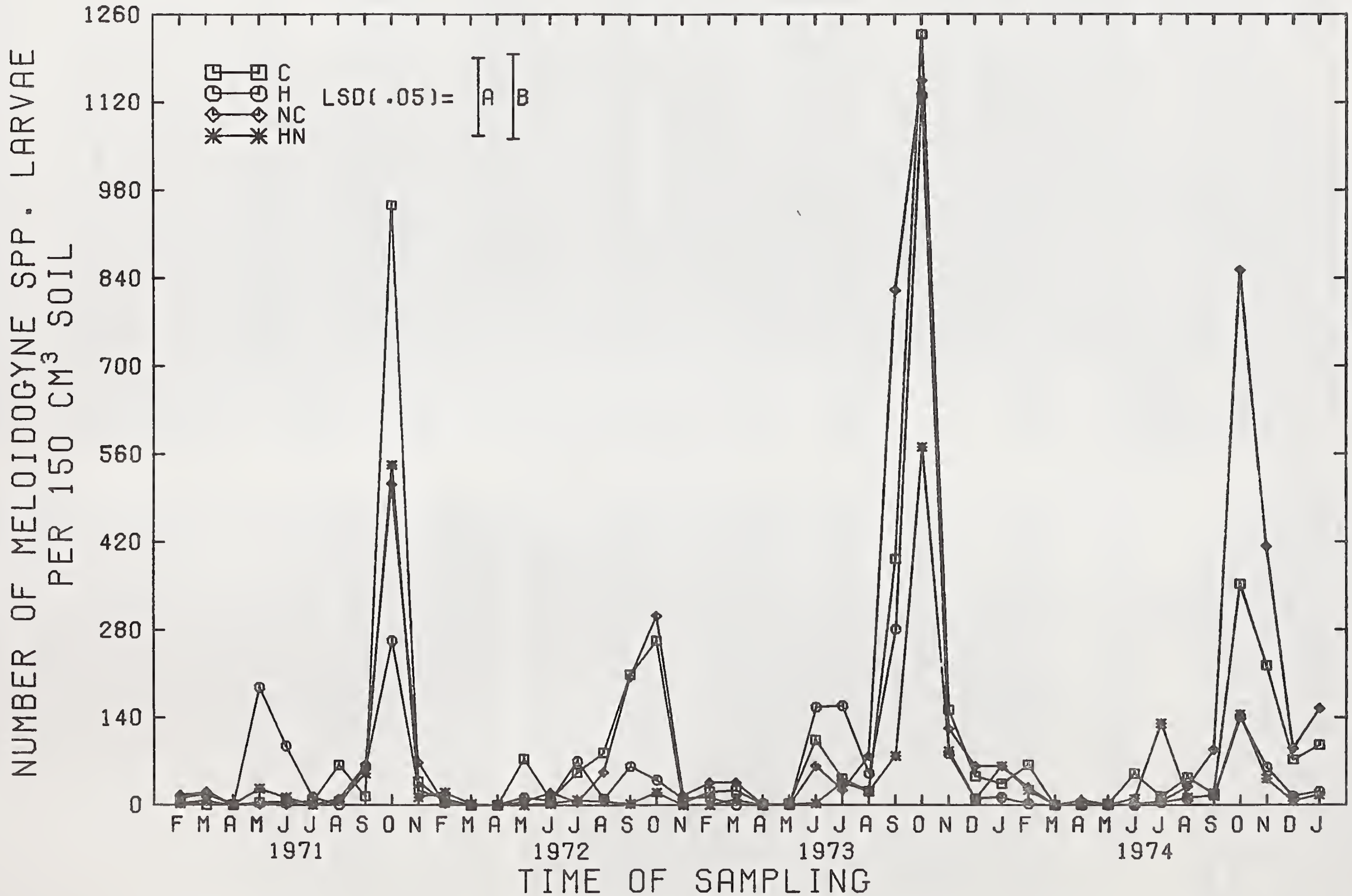

FIGURE 1.—Seasonal fluctuations of *Meloidogyne* spp. on a snap bean-soybean-cabbage (SNB-SB-CB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

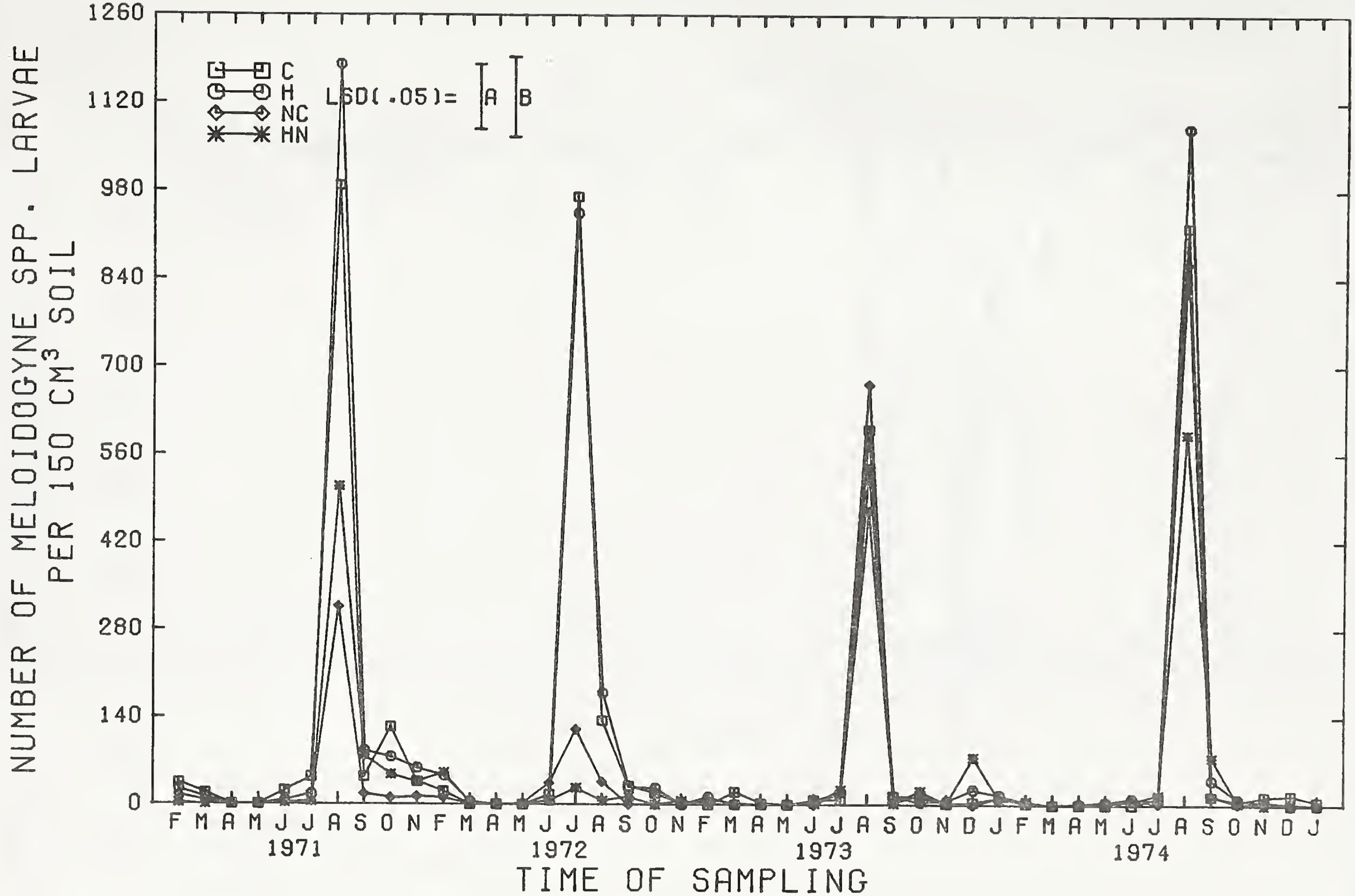

FIGURE 2.—Seasonal fluctuations of *Meloidogyne* spp. on a turnip-cucumber-southernpea-turnip (T–CU–SP–T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

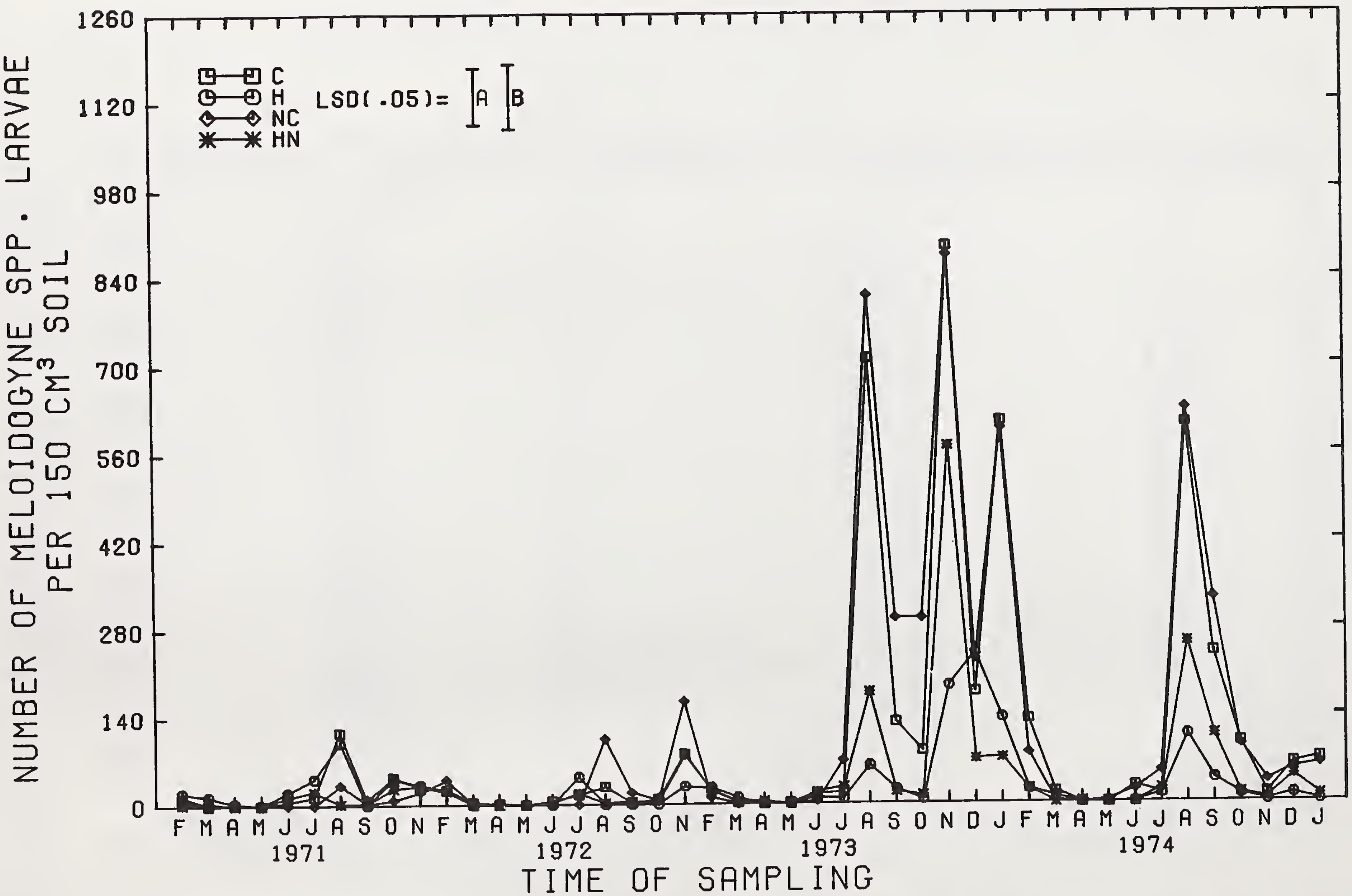

FIGURE 3.—Seasonal fluctuations of *Meloidogyne* spp. on a turnip-corn-snap bean (T-C-SNB) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

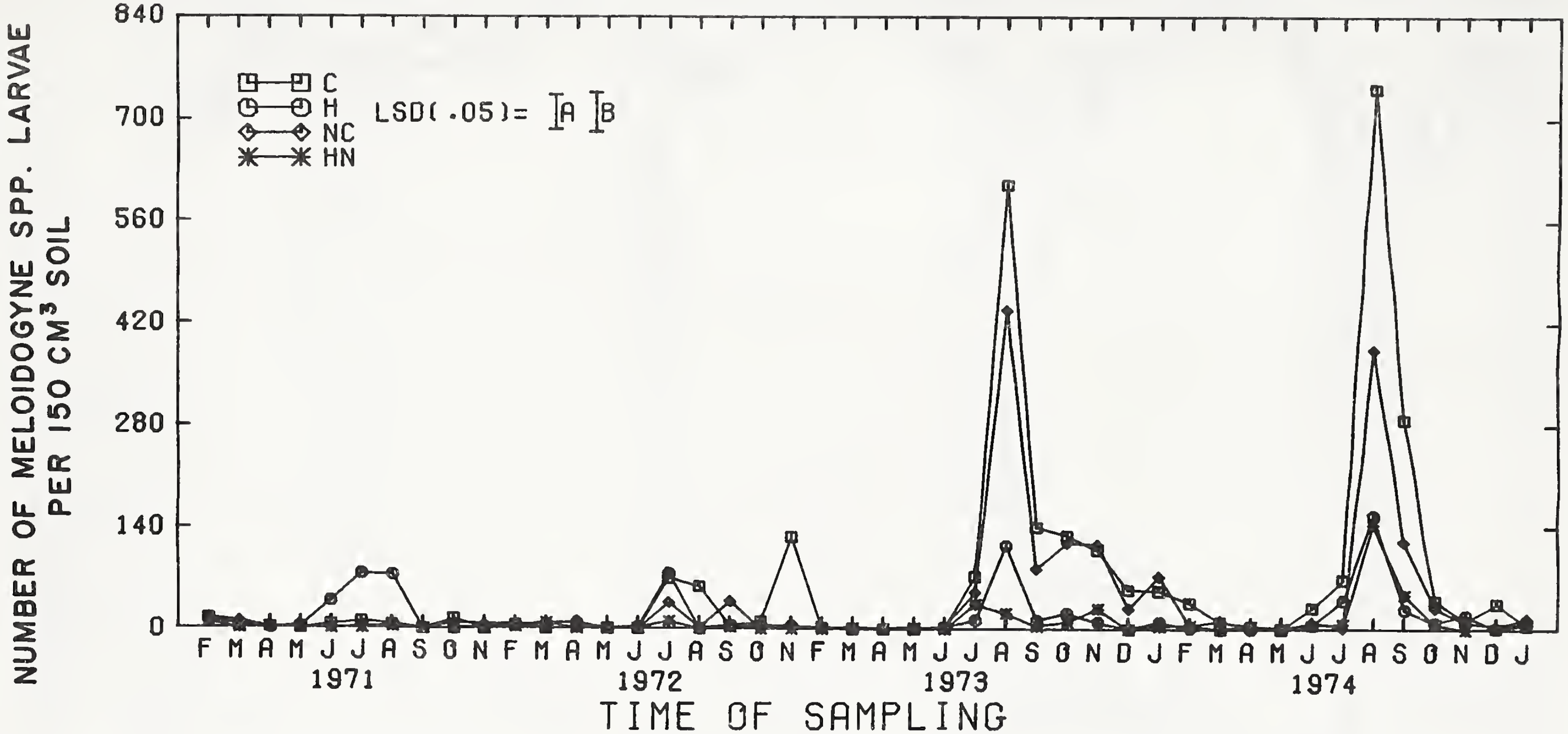

FIGURE 4.—Seasonal fluctuations of *Meloidogyne* spp. on a turnip-corn-turnip (T-C-T) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

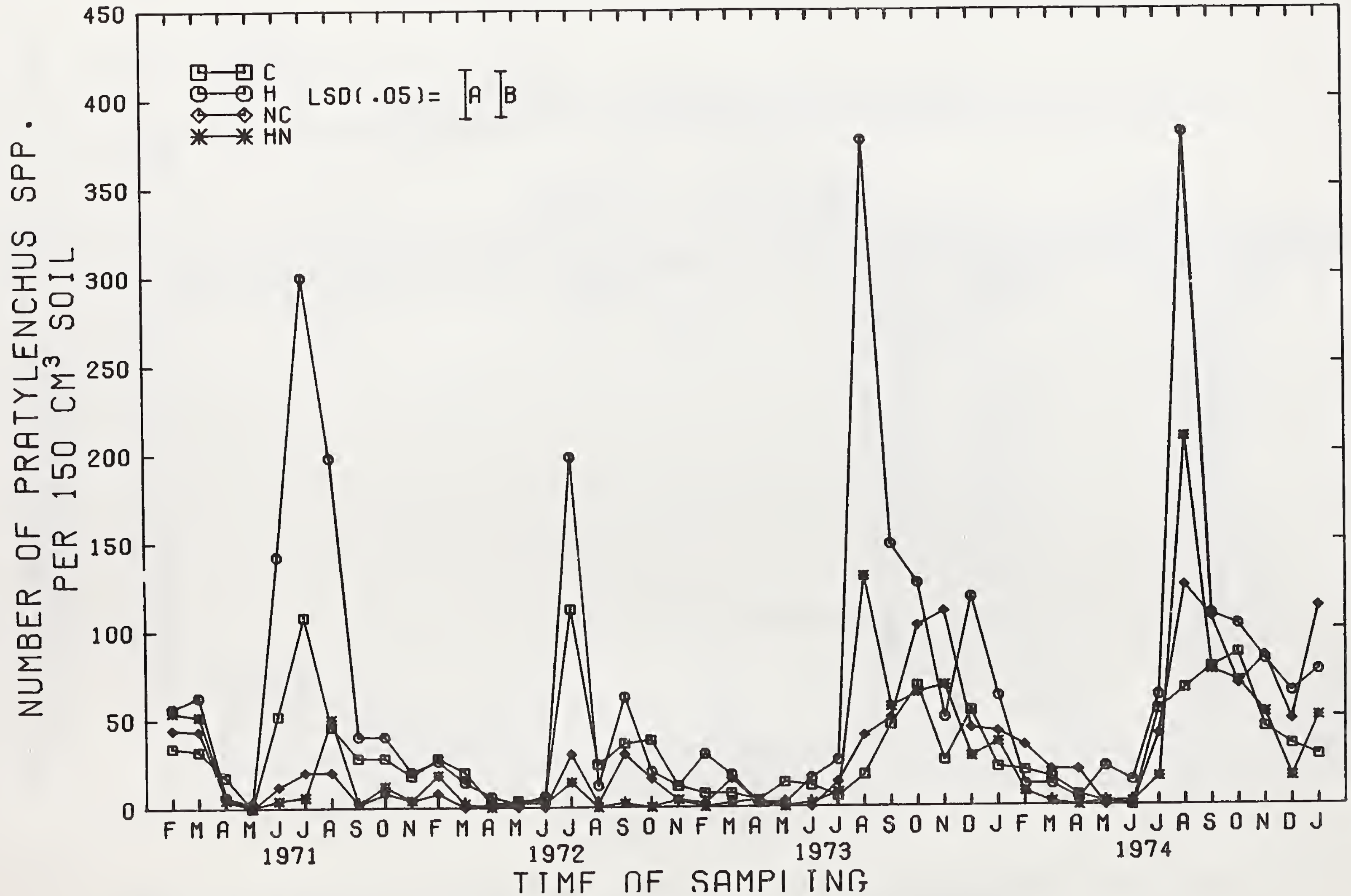

FIGURE 5.—Seasonal fluctuations of *Pratylenchus* spp. on a turnip-corn-turnip (T-C-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

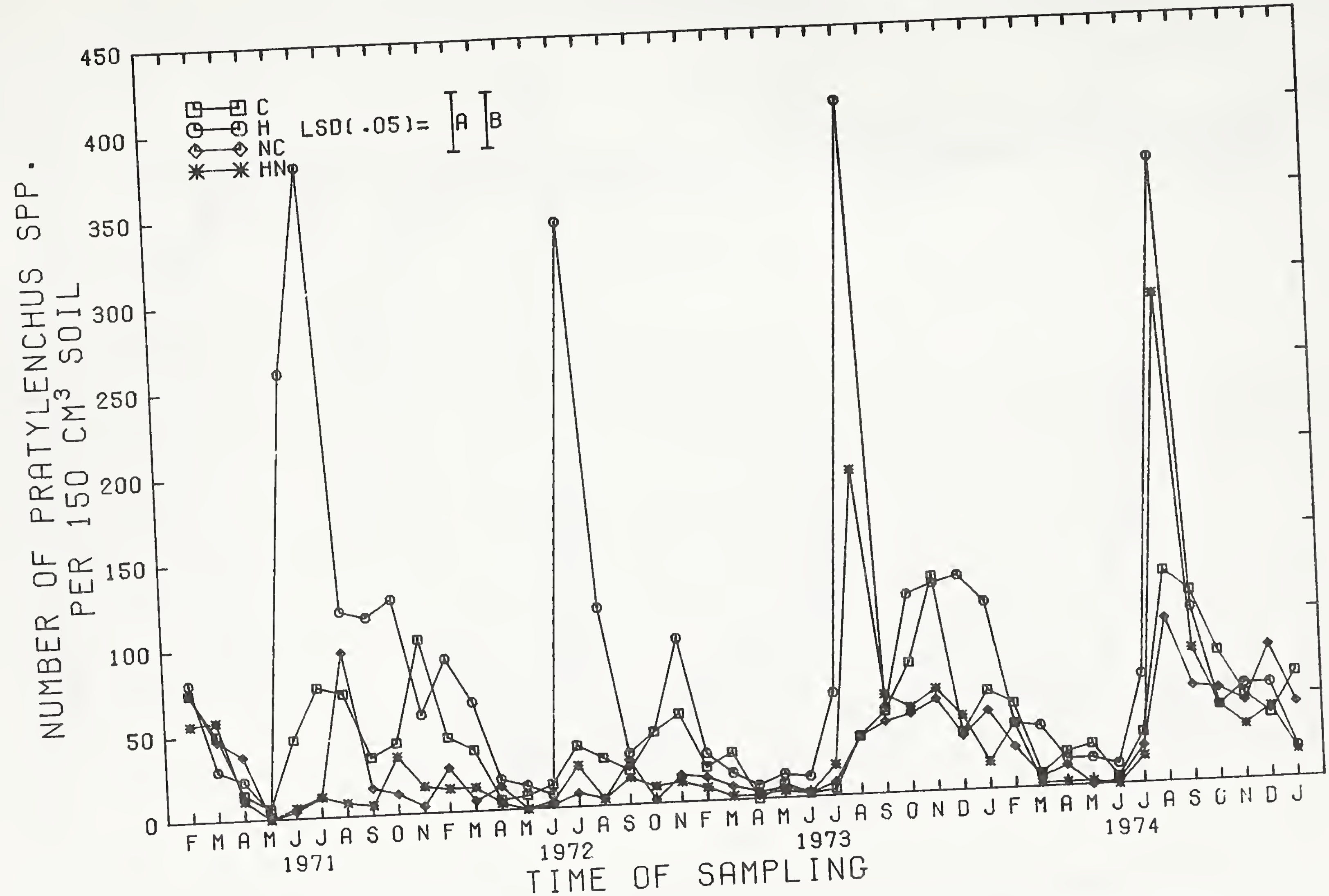

FIGURE 6.—Seasonal fluctuations of *Pratylenchus* spp. on a turnip-corn-snap bean (T-C-SNB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

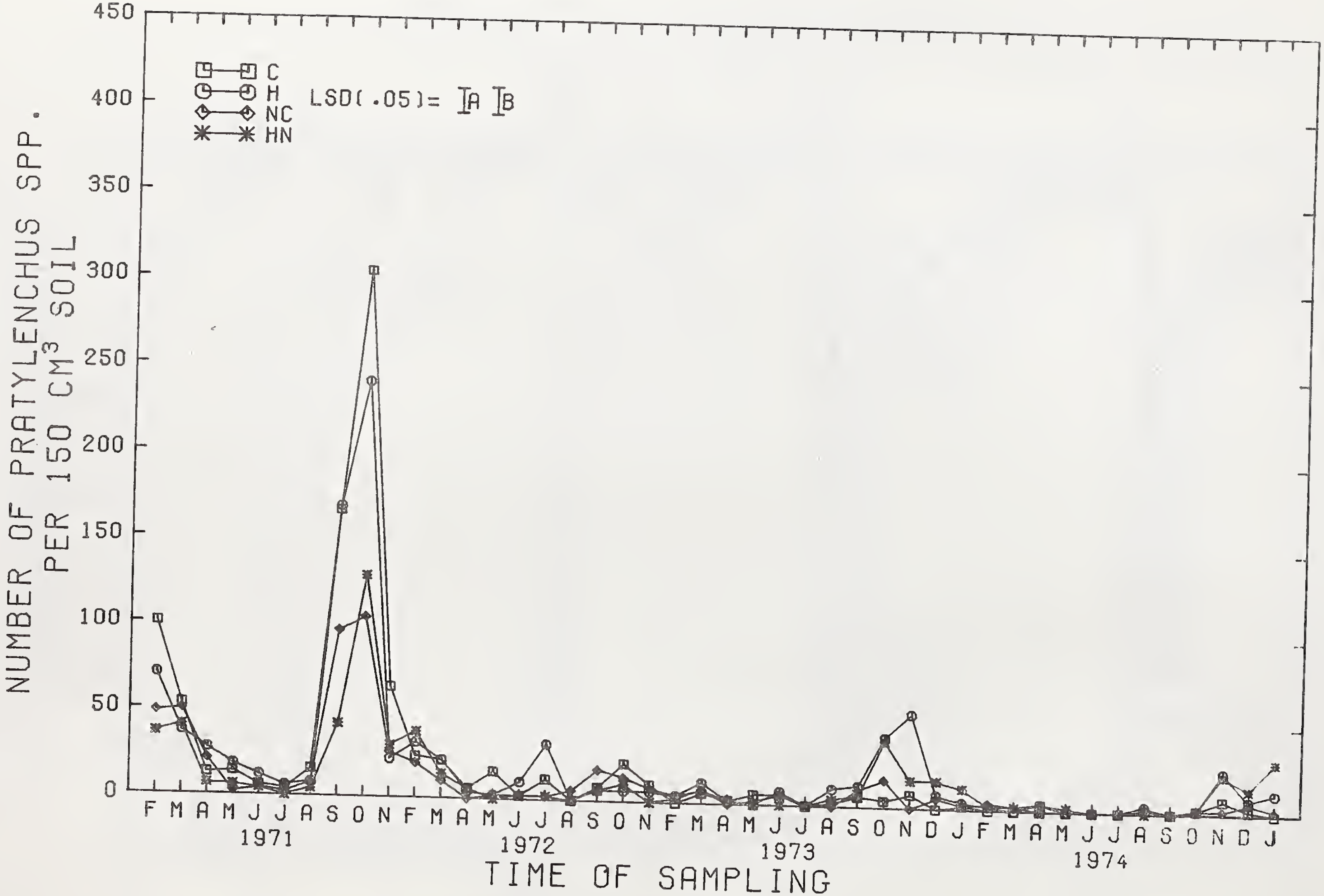

FIGURE 7.—Seasonal fluctuations of *Pratylenchus* spp. on a snap bean-soybean-cabbage (SNB-SB-CB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

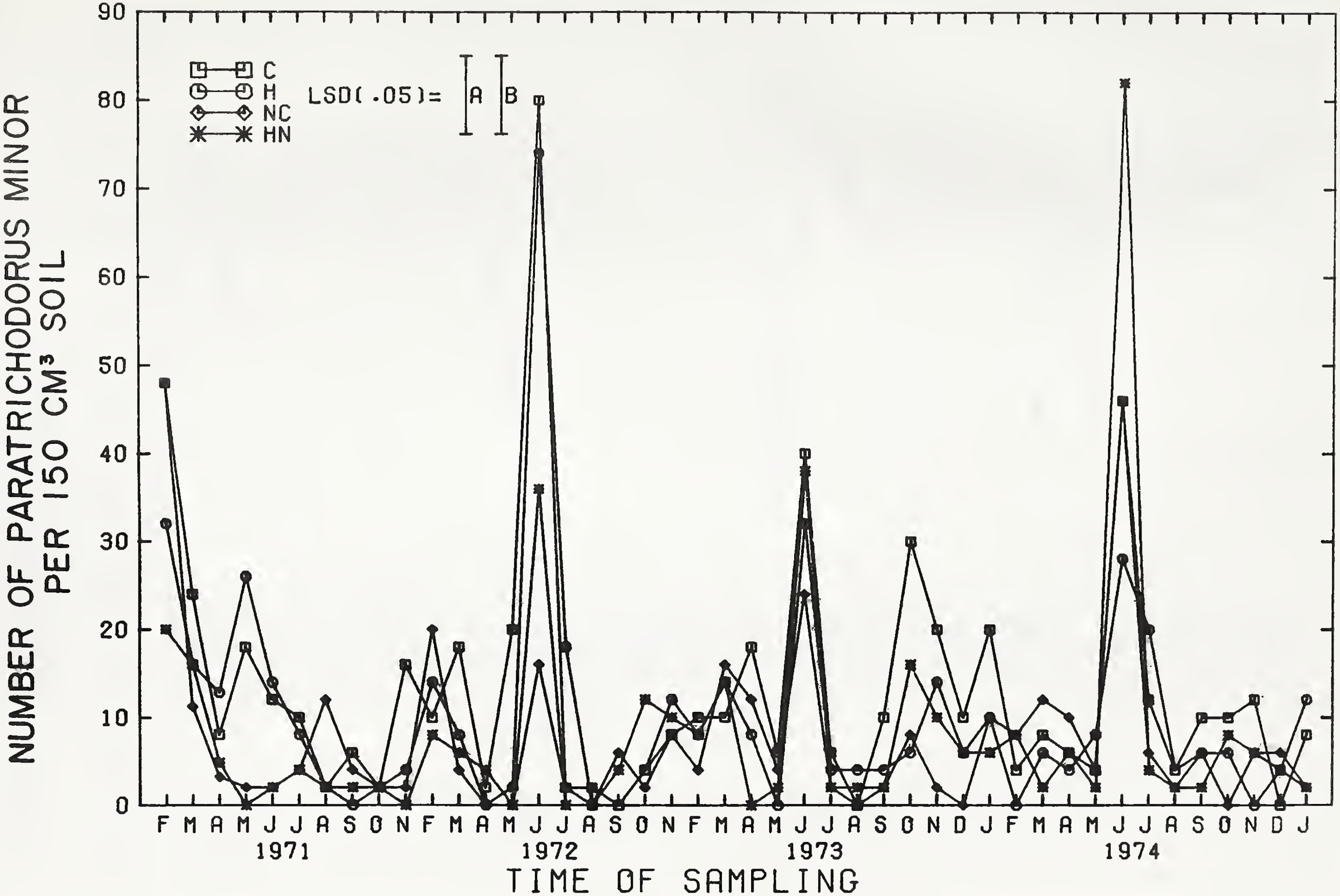

FIGURE 8.—Seasonal fluctuations of *Paratrichodorus minor* on a turnip-corn-snap bean (T-C-SNB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

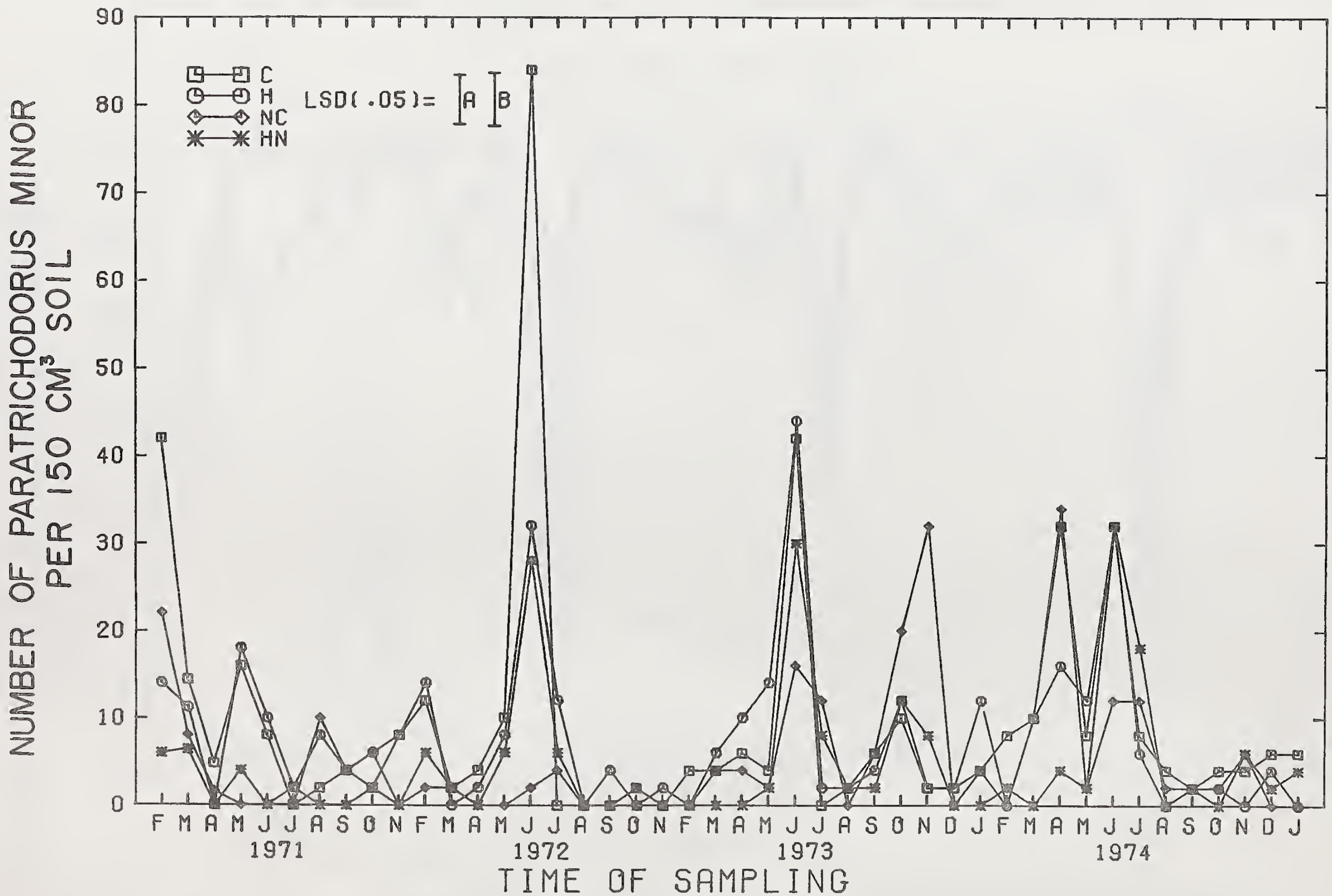

FIGURE 9.—Seasonal fluctuations of *Paratrichodorus minor* on a turnip-corn-turnip (T-C-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

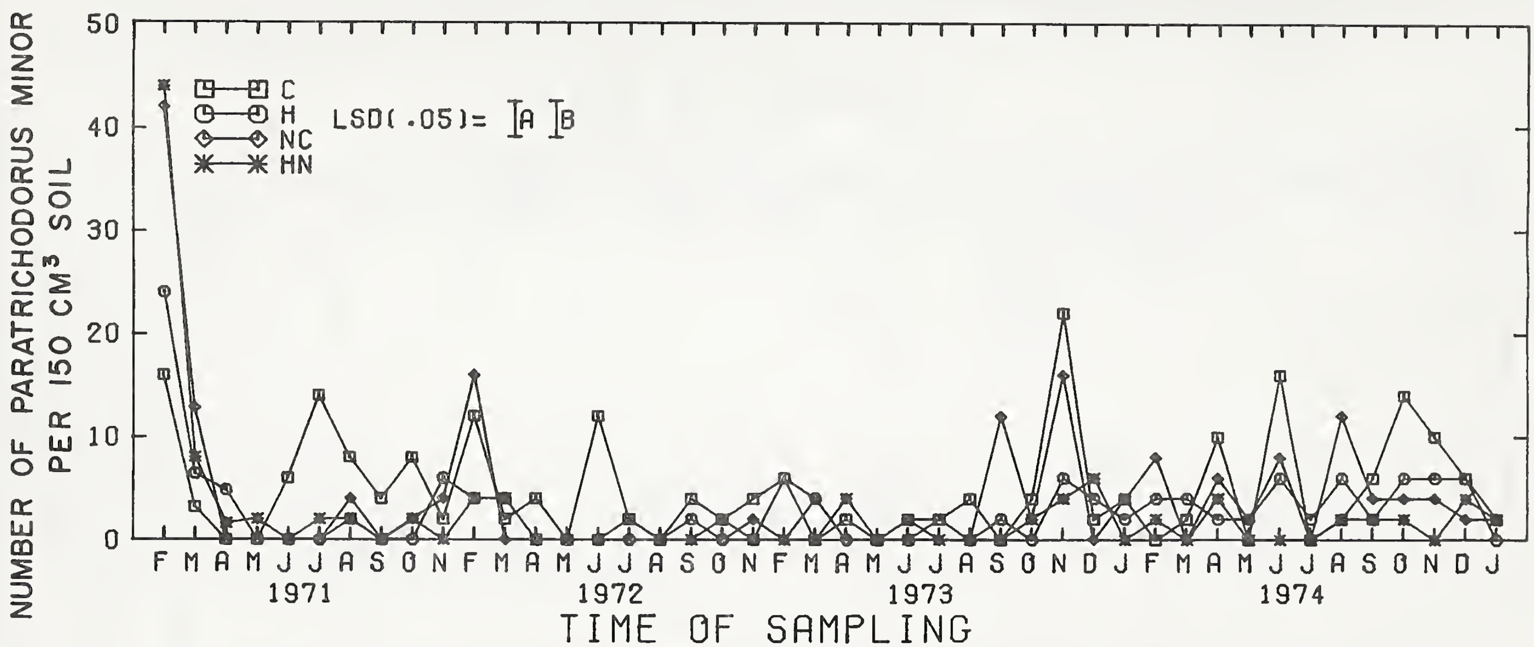

FIGURE 10.—Seasonal fluctuations of *Paratrichodorus minor* on a turnip-peanut-snap bean (T-P-SNB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

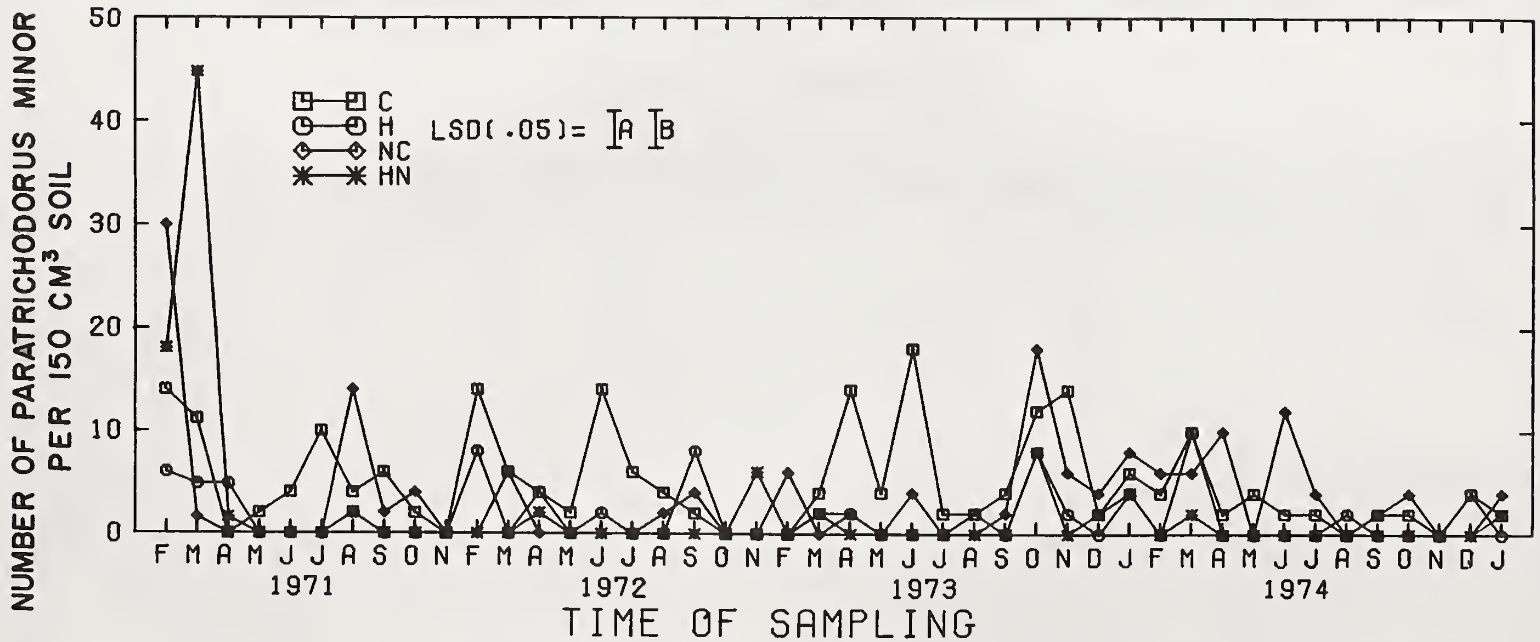

Figure 11.—Seasonal fluctuations of *Paratrichodorus minor* on a turnip-peanut-turnip (T-P-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

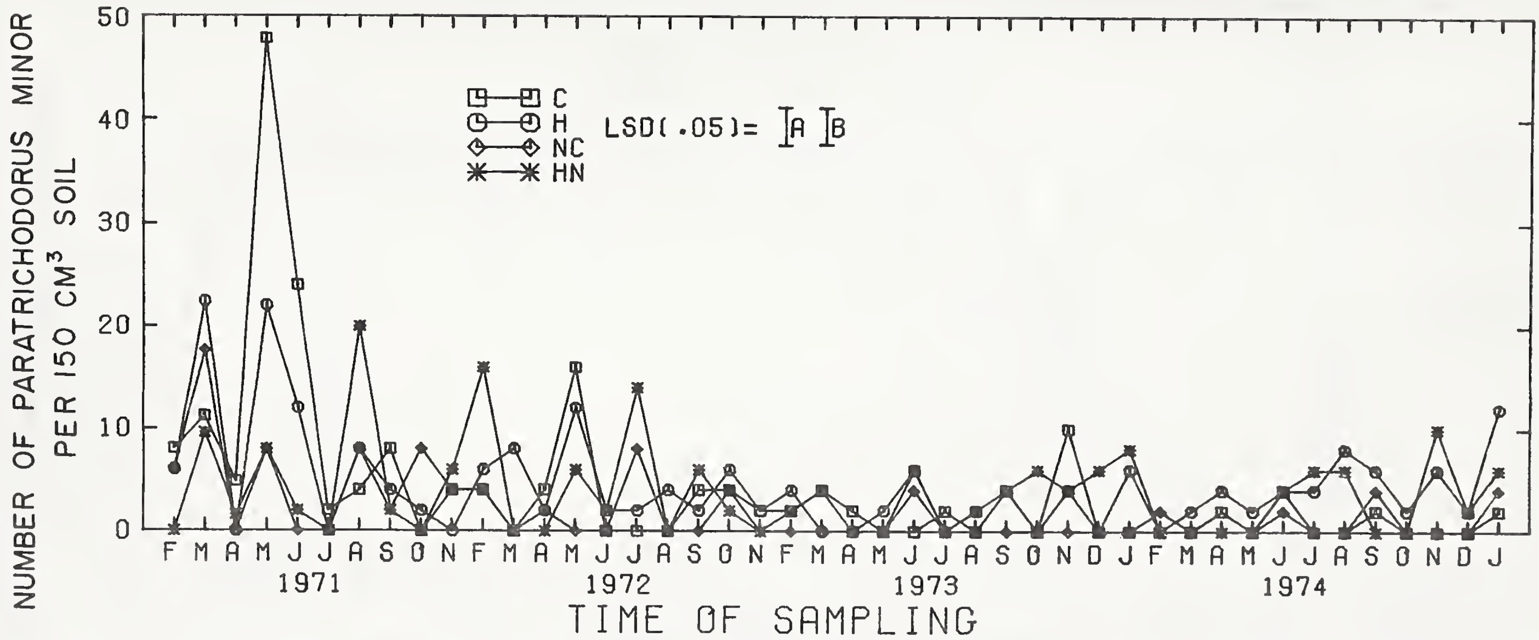

FIGURE 12.—Seasonal fluctuations of *Paratrichodorus minor* on a snap bean-soybean-cabbage (SNB-SB-CB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

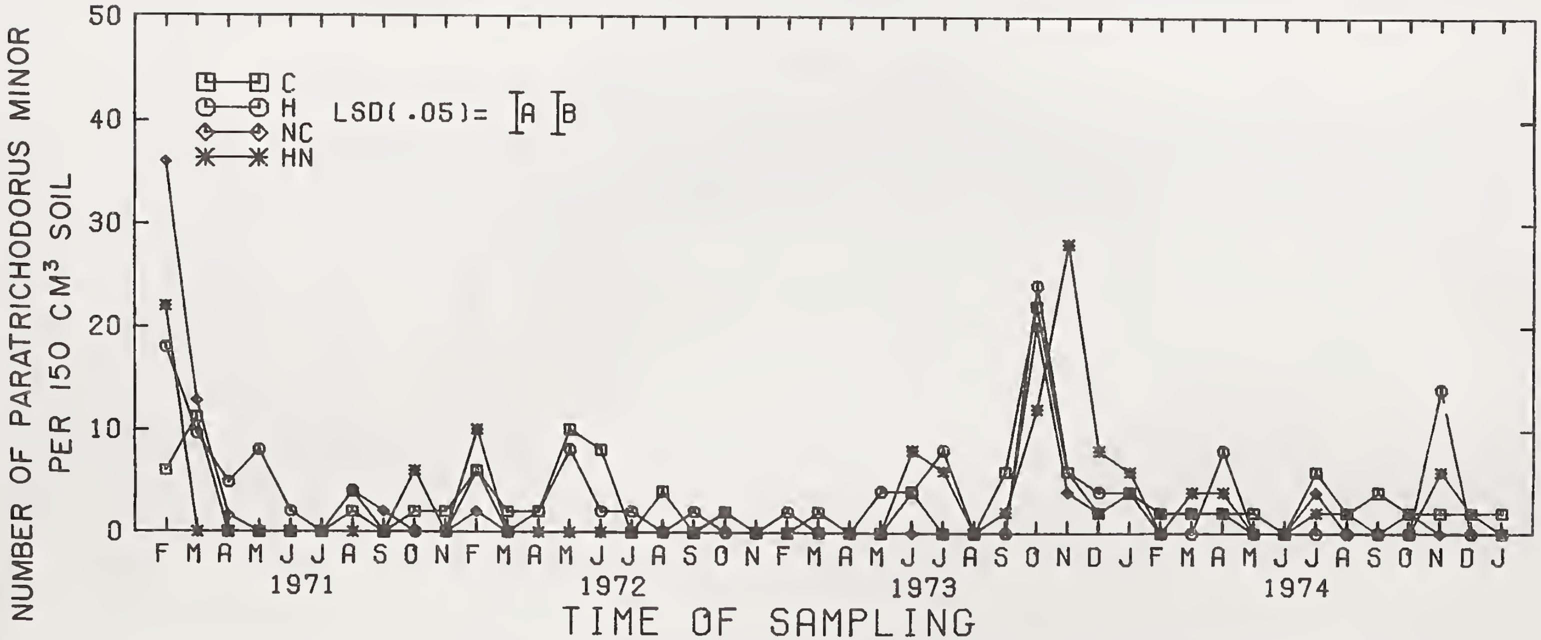

FIGURE 13.—Seasonal fluctuations of *Paratrichodorus minor* on a turnip-cucumber-southernpea-turnip (T-CU-SP-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

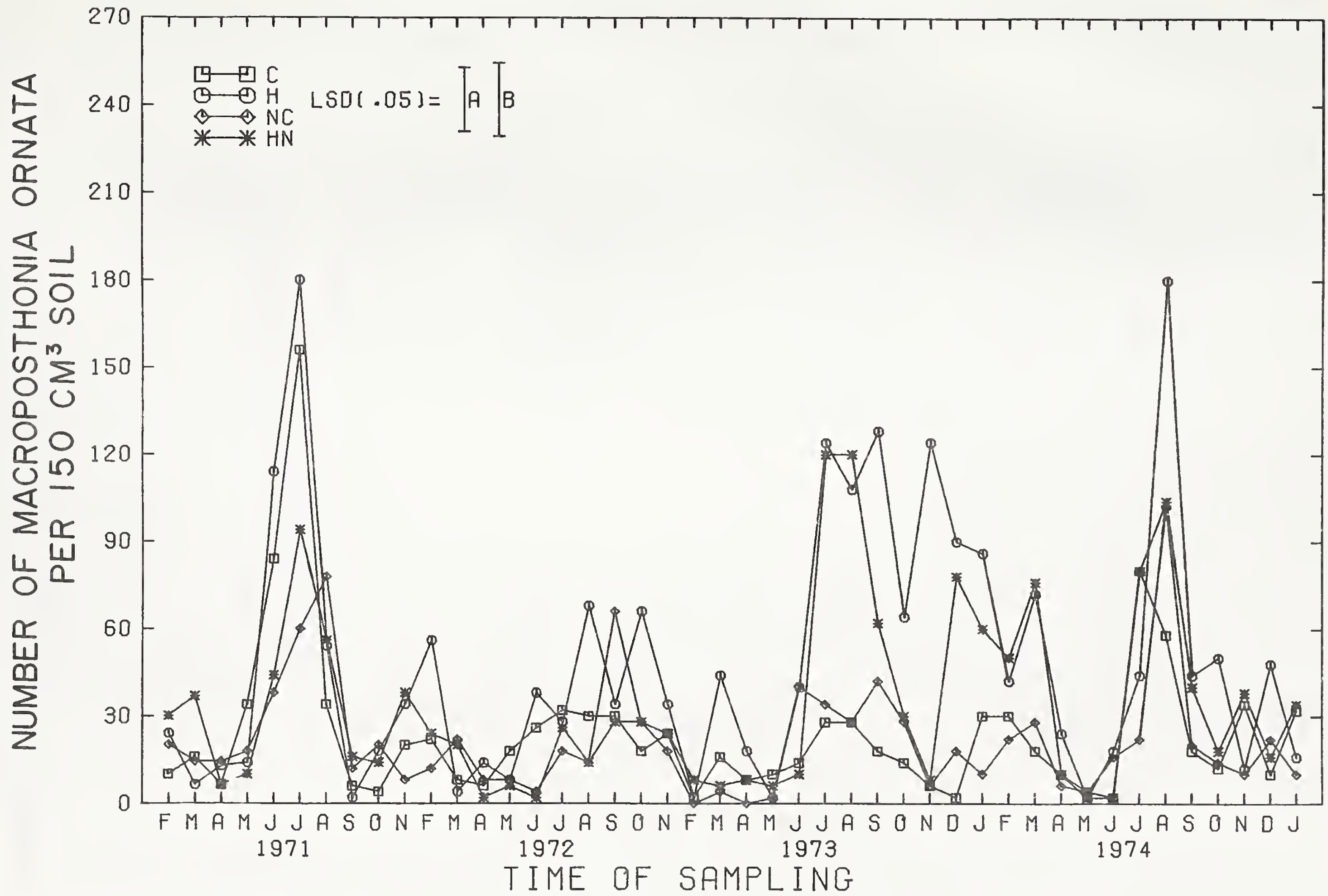

FIGURE 14.—Seasonal fluctuations of *Macroposthonia ornata* on a turnip-peanut-turnip (T-P-T) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

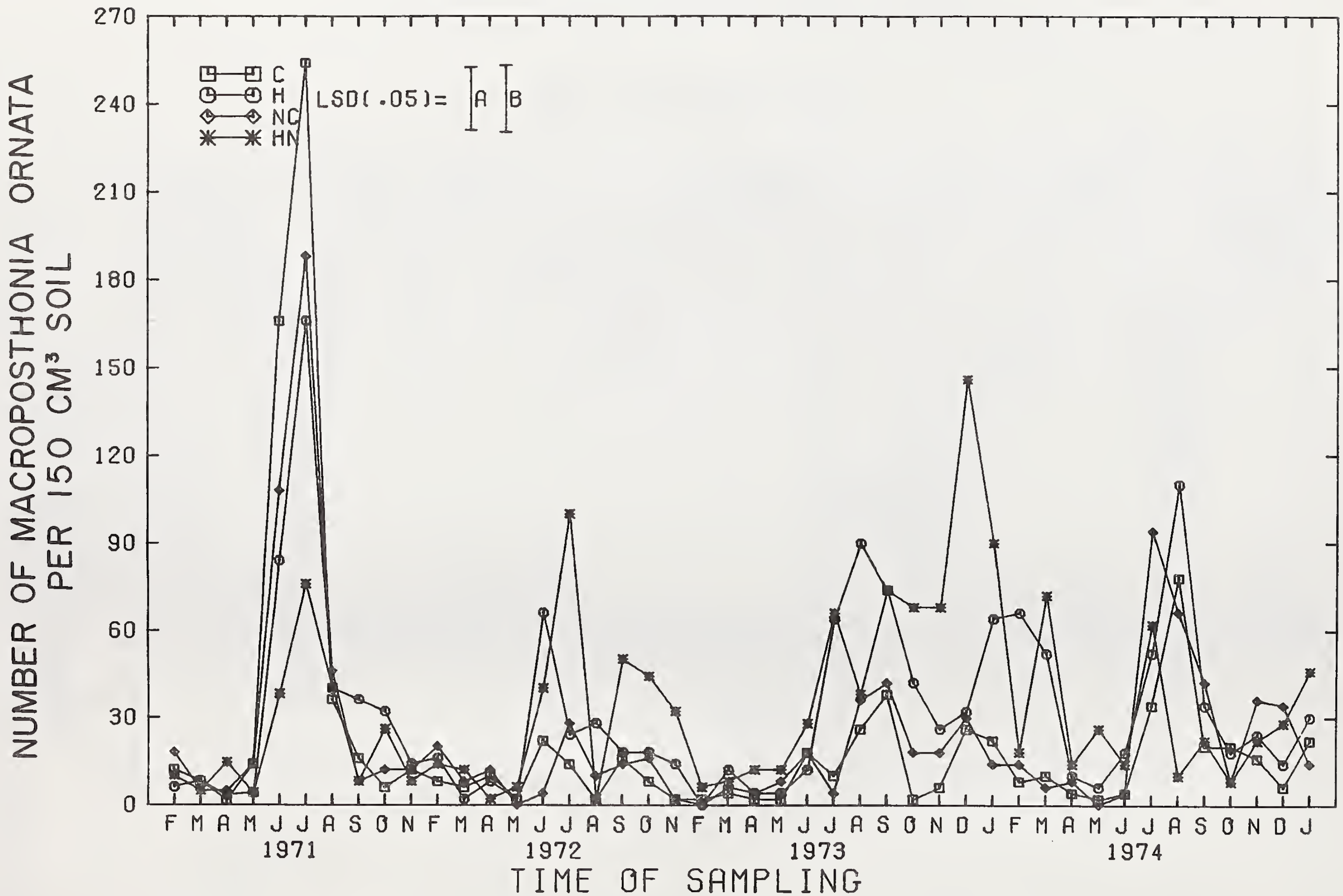

FIGURE 15.—Seasonal fluctuations of *Macroposthonia ornata* on a turnip-peanut-snap bean (T-P-SNB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

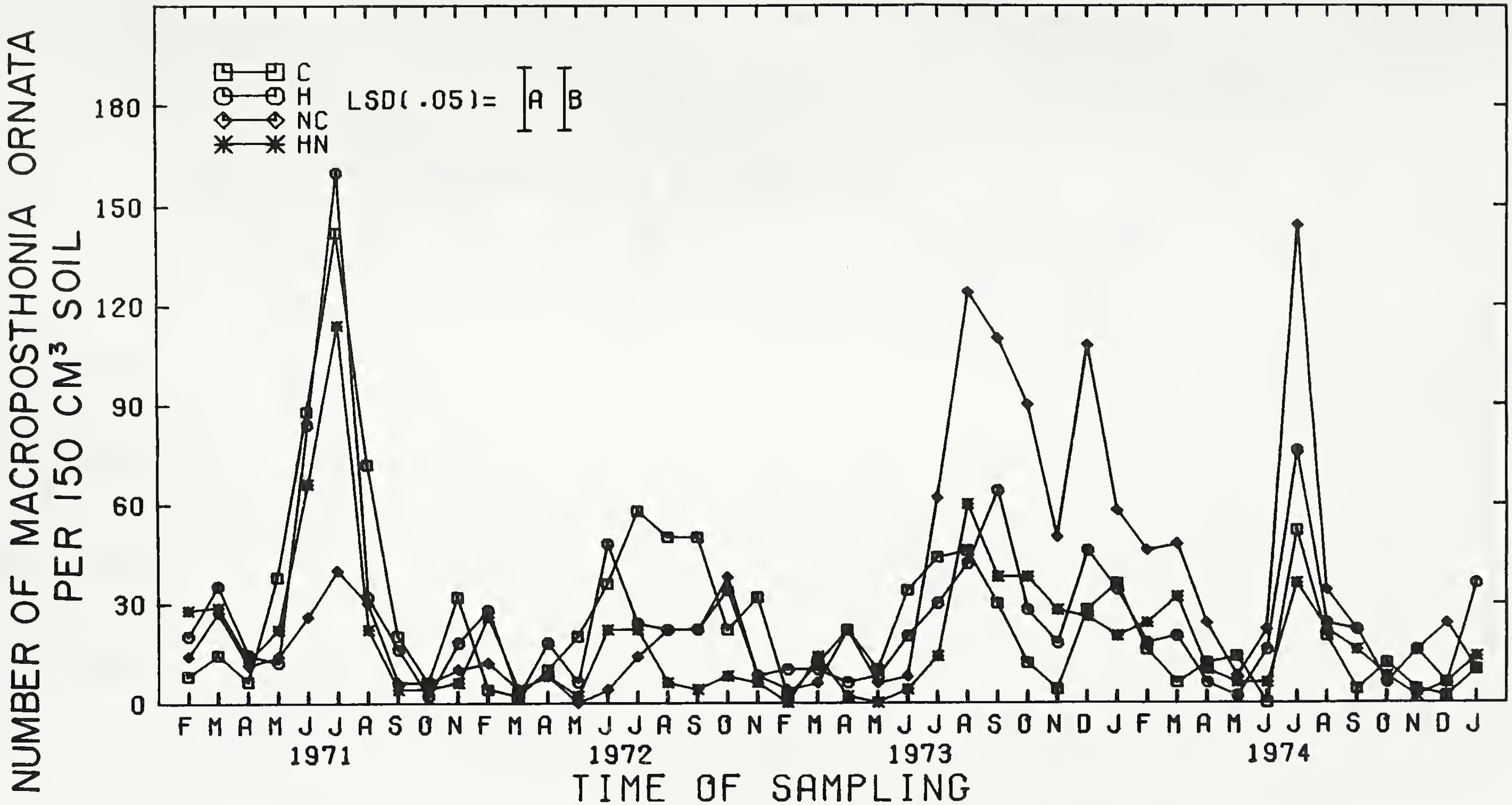

FIGURE 16.—Seasonal fluctuations of *Macroposthonia ornata* on a turnip-corn-turnip (T-C-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

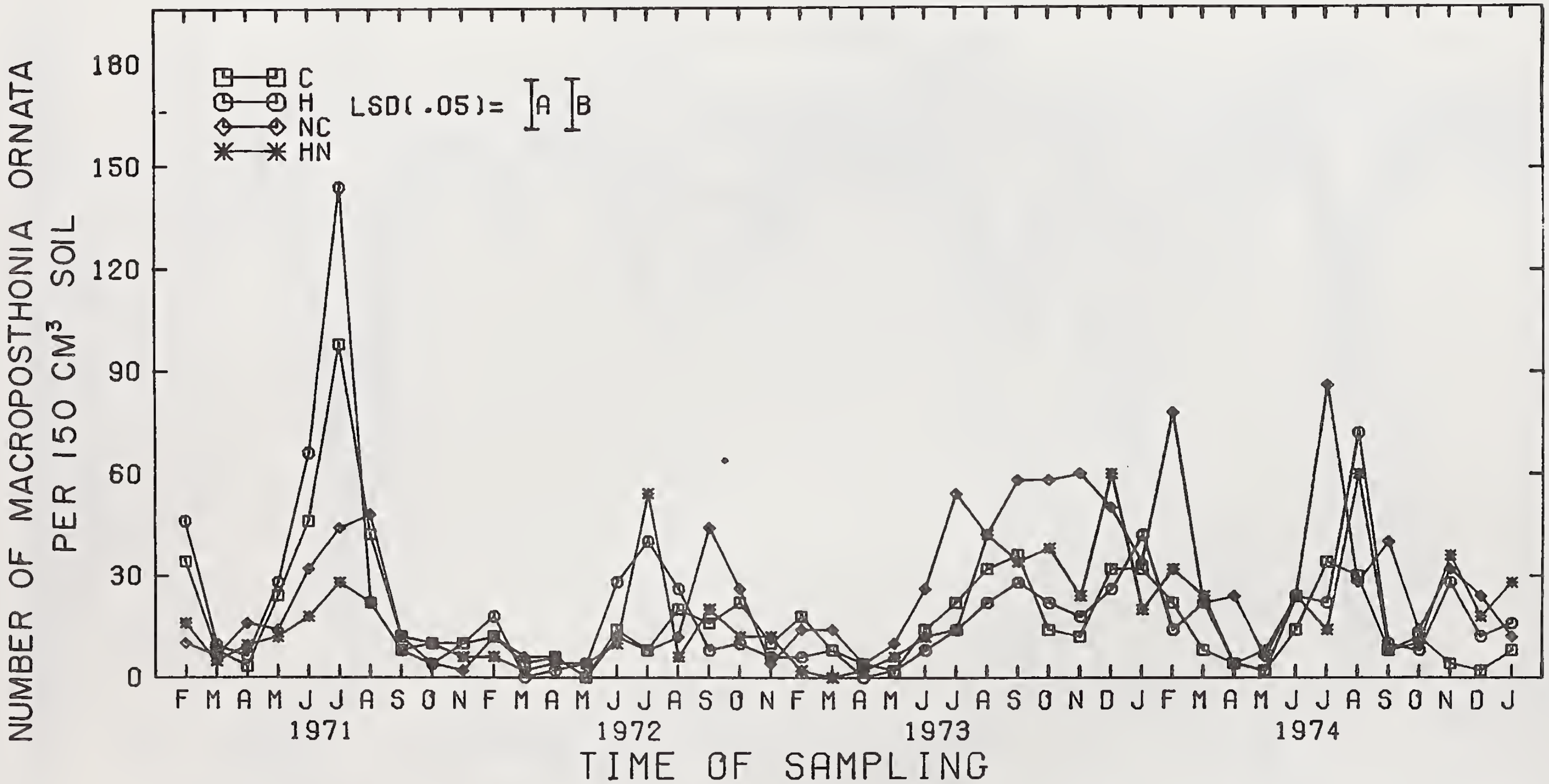

FIGURE 17.—Seasonal fluctuations of *Macroposthonia ornata* on a turnip-corn-snap bean (T-C-SNB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

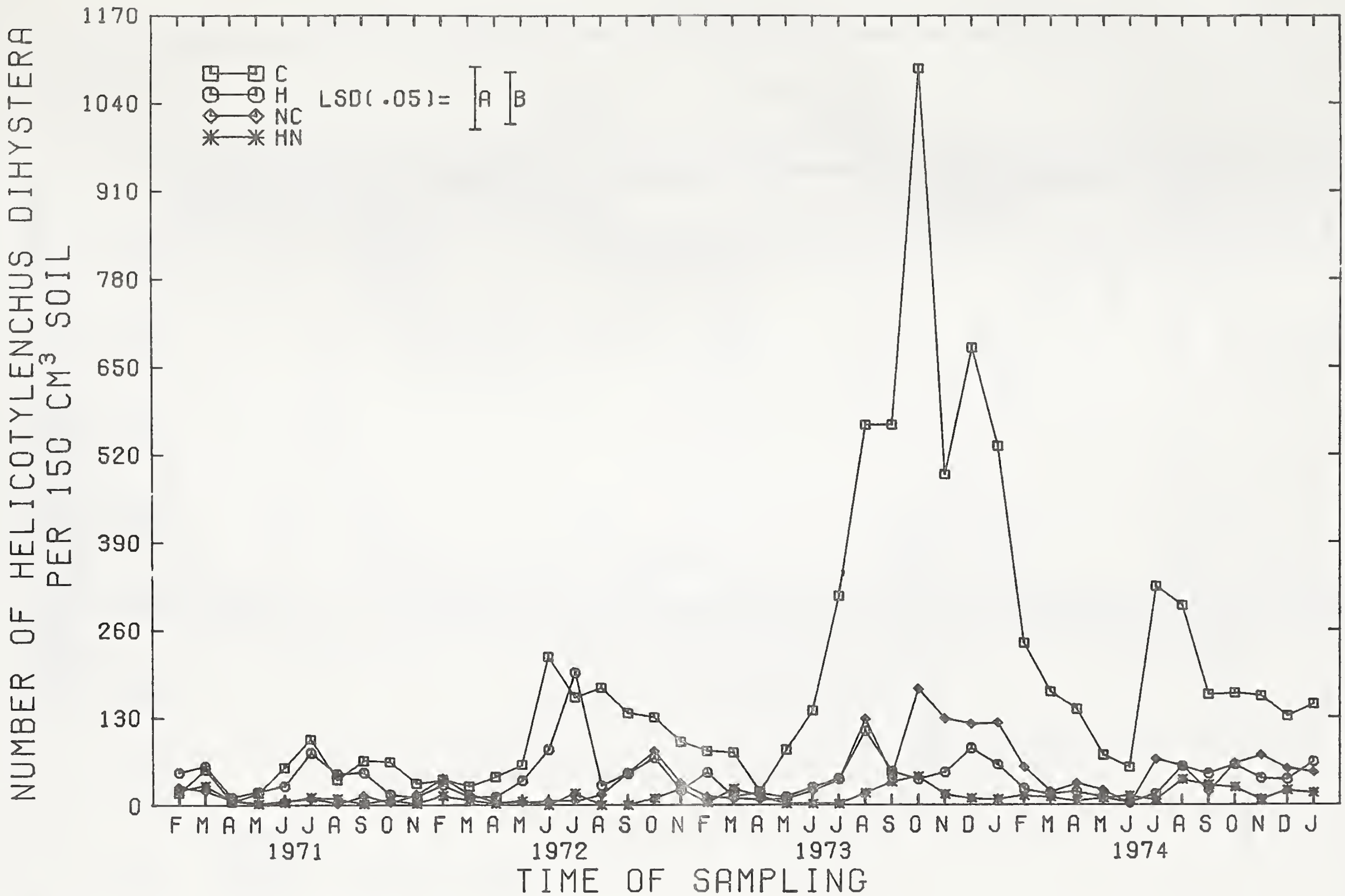

FIGURE 18.—Seasonal fluctuations of *Helicotylenchus dihystera* on a turnip-corn-turnip (T-C-T) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

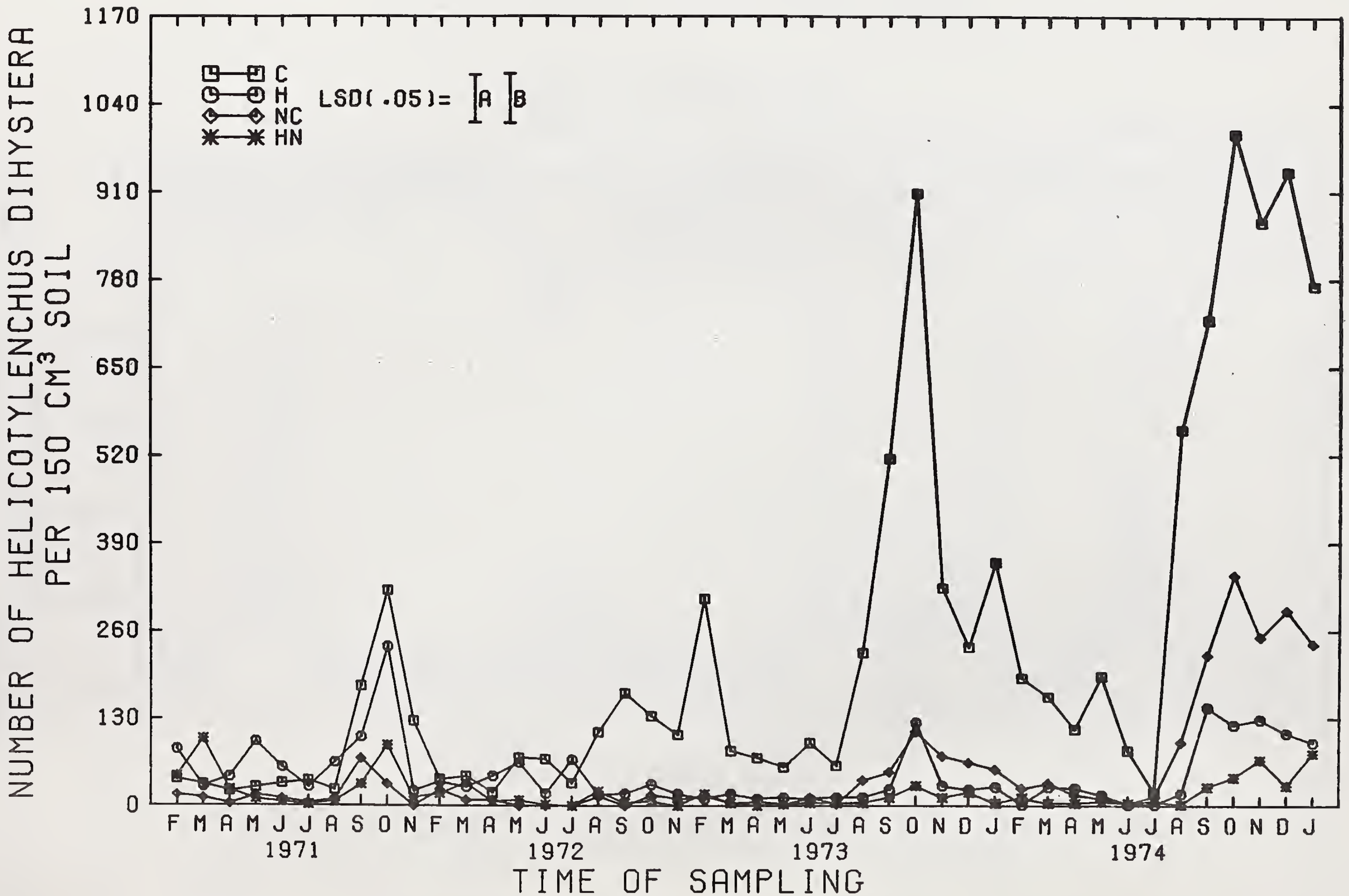

FIGURE 19.—Seasonal fluctuations of *Helicotylenchus dihystera* on a snap bean-soybean-cabbage (SNB-SB-CB) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

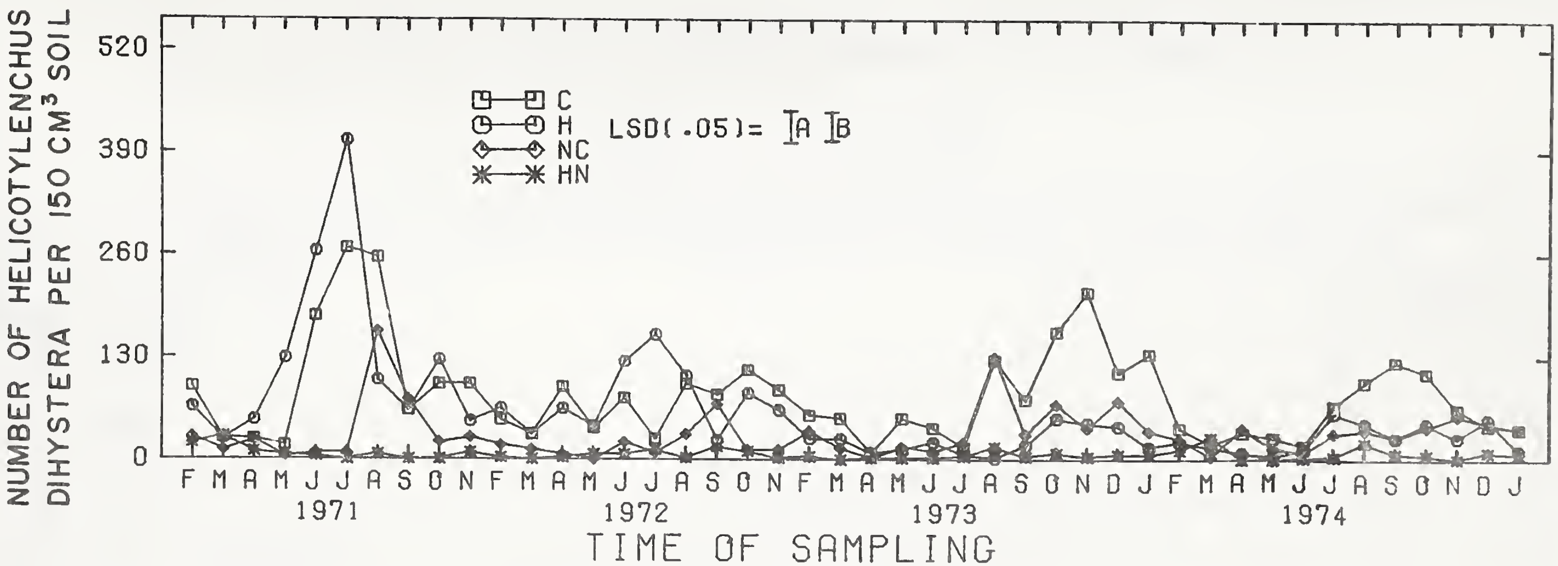

FIGURE 20.—Seasonal fluctuations of *Helicotylenchus dihystera* on a turnip-corn-snap bean (T-C-SNB) cropping sequence, 1971–74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

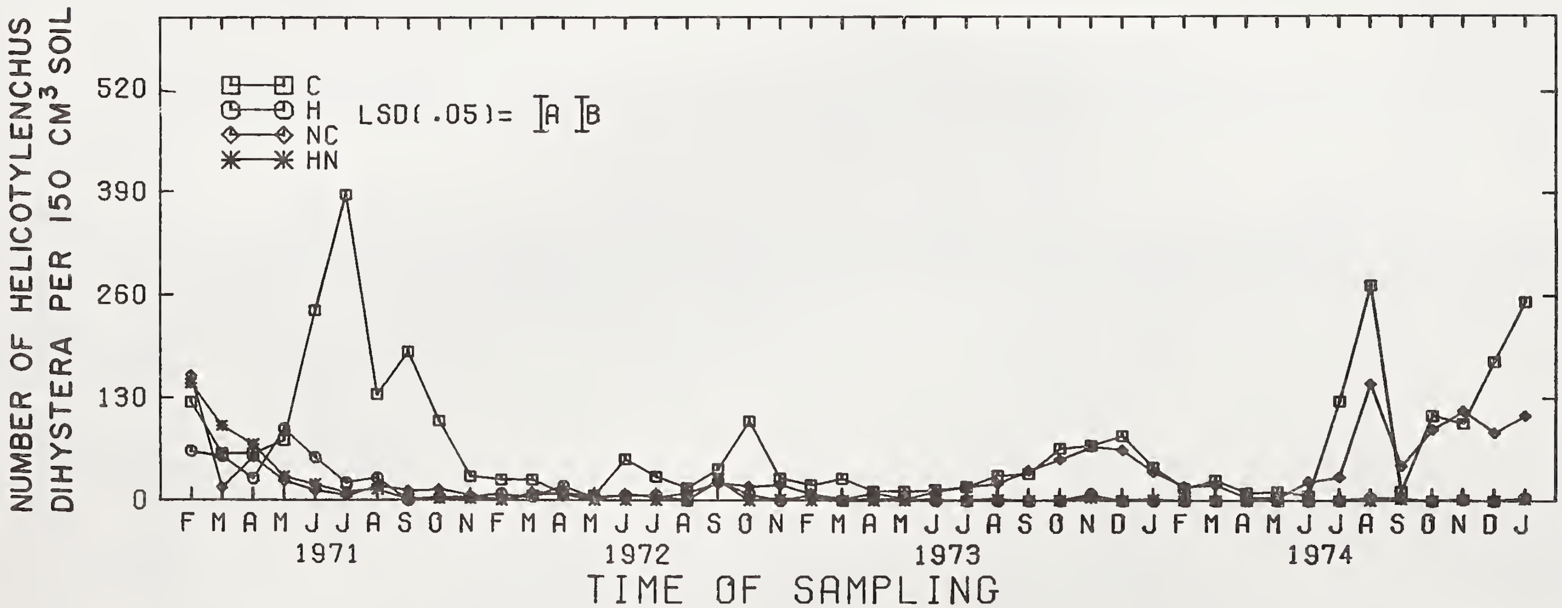

FIGURE 21.—Seasonal fluctuations of *Helicotylenchus dihystera* on a turnip-peanut-turnip (T-P-T) cropping sequence, 1971-74. C, cultivation. H, herbicide. NC, nematicide + cultivation. HN, herbicide + nematicide.

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